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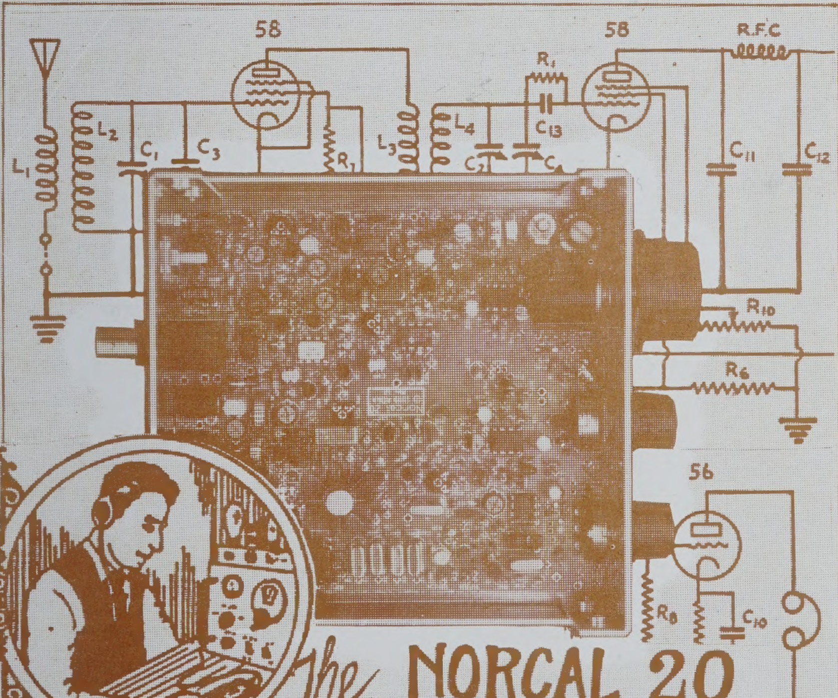
QRPp

Special Pre-Millenium Issue

NC20 & 2N2/40 Updates, Construction, Antenna's, & more.



The NORCAL 20

Journal of the Northern California QRP Club

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From the Editor

by Doug Hendricks, KI6DS

Just a very short column this time, as there is so much to print and so little space available. We wanted to provide you with some projects to build using the Manhattan style of construction that was featured in the last issue, and believe that we have done it here. Note that the back issues for 1998, Volume 6 are now available, but the price has gone up to $20 for the book, $4 for P&H in the US, higher for DX. Please see the inside back cover for details.

We realize that the past two issues have been out later than we would prefer, but we are doing this as a hobby, we are a club publication, and we ask for your patience and understanding. We do make every effort to be on time, but sometimes we don't make it. Thank you for your support. Congratulations to Dave Benson, Paul Harden and L.B. Cebik on their election to the QRP Hall of Fame. Well deserved. 72, Doug, KI6DS

The Bushmaster Antenna

by Joseph Street, VE3UXE
102 Cornerbrook Creek
Waterloo, ON N2V1L2 Canada

In assembling a portable HF radio station there are a great many considerations to take into account. This is especially true in the case of a station to be used in wilderness backpacking. Not the least of these considerations is the choice of antenna. The antenna must be small and lightweight and have good efficiency, which is very important when operating QRP. Also of prime importance is the minimization of feedline losses which leaves one with the choice of an antenna which is fed near the ground, or the use of large quantities of low loss feedline which is normally bulky and/or heavy. When operating in the wilderness, trees are the obvious choice for antenna support, but can also be an obstacle to success when in dense forest. Vertical antennas are fairly easy to erect but their efficiency is low unless used with a near perfect ground, and their low radiation angle may be less than desirable for some. While a dipole is more tolerant of a poor ground, it needs to be raised to a decent height which can be a real challenge in dense forest, and there are the aforementioned problems with the feedline to contend with. What is really needed in this particular case is an antenna which can be erected close to the ground, have good efficiency, and radiate at high as well as low angles, while being small and light enough to stick in your pocket, and cost less than 20 bucks to boot. The question is, what kind of antenna can meet all of these requirements? The answer of course, as any Red Green fan would know, is to use duct tape!

Having had success with a commercially made small loop with QRP opera-

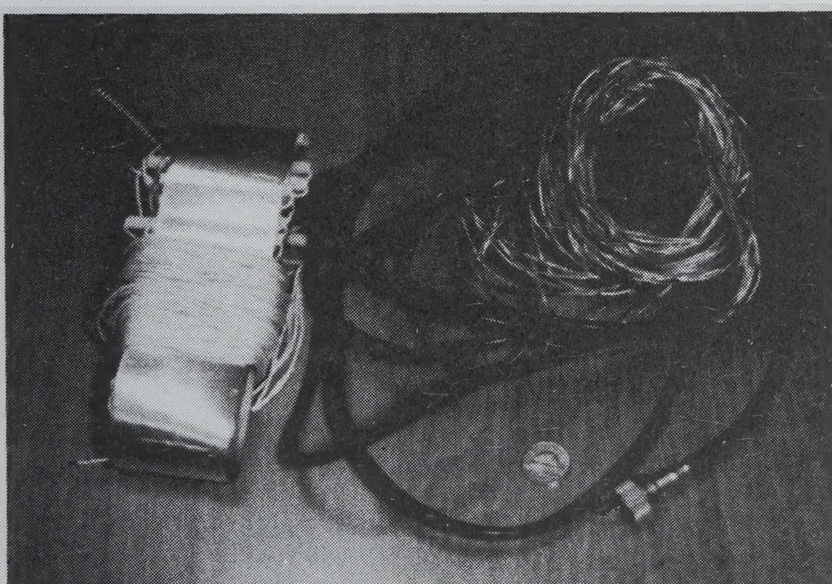


Photo 1: The complete antenna packed for travel.

tion from the home shack, I decided to try to build something portable along these lines. After reading about the small transmitting loop described in the ARRL Antenna Handbook, I was inspired to replace the copper tubing with aluminum foil. I also deviated from the design described in the handbook in the means of matching the loop to the feedline, but essentially the antenna is the same. The antenna is well known and well described in the handbook so only a brief overview of the theory of its operation will be given here.

The antenna takes the form of a single turn inductor with the ends connected by a series tuning capacitor. This is simply a tank circuit which has a high to very high Q, depending on the amount of loss resistance in the tank circuit components. Keeping loss resistances down is paramount to producing an efficient loop antenna. Forget about using wire for a small transmitting loop. Commercial units are constructed with large diameter tubing and split stator capacitors using all welded construction to reduce the loss resistance which must be in the milliohm range for decent efficiency. This design uses a continuous strip of wide flat aluminum foil to form both the loop conductor as well as the tuning capacitor. This approach ensures that losses are kept to a minimum. The antenna which has a very low radiation resistance, on the order of one ohm, may be matched to the transmission line by various means, but in this particular case, link coupling is used to reduce loss. If one examines the formulae for this type of antenna as given in the handbook it is interesting to note that as the area of the loop increases the radiation resistance increases which translates as an increase in efficiency , assuming loss resistance is kept low. Also when radiation resistance increases, Q is reduced yielding an increase in usable bandwidth. The text also notes that when the circumference of the loop reaches somewhere between a quarter to one third of a wavelength, the loop becomes self resonant and the tuning capacitor loses its ability to tune the loop. I speculated that if the loop were made long enough to be self resonant then the bandwidth might be large enough to cover the entire 50 Khz of the 30 meter band I was interested in.

In building several iterations of the design it became apparent that the circumference of the loop should be kept slightly smaller than the self resonant length. It is desirable that some tuning capacitance be needed to resonate the loop at the desired frequency. This is useful to compensate for the different loading effects of erecting the antenna in different locations, which affects its resonance. As long as the loop is not too small the Q will be low enough to afford plenty of bandwidth. One version of the loop which had a circumference of 16 feet showed a bandwidth of 200 Khz on the 20 meter band between the 2:1 SWR points.

Construction of the antenna is simple. I used a single piece of 2 inch wide aluminum foil duct tape to form both the loop inductor and tuning capacitor sections. 3 inch wide material is also available and should reduce loss especially for the lower frequency designs. Regardless of what size you use, it MUST be aluminum foil, not the fiber type duct tape which is more common. Begin by cutting the tape to a quarter wavelength or slightly less according to your needs, but remember the shorter it is the lower the useable bandwidth will be. I laminated the tape to a strip of 0.004" thick polyethylene plastic to add strength and support to the aluminum foil. The capacitor is created by making a hinged section out of a couple of 2 inch wide strips of Plexiglas 4 to 5 inches long. The dimensions are not critical. Stack the two plates and drill a 1/8" hole through both

the plates opposite to where the hinge will be. Enlarge the hole in one of these plates to 7/32", and tap it with 1/4-28 threads. This is for the tuning screw which I made by threading a short section of hard plastic tubing with the matching male thread. The tuning capacitor is made by taping each end of the duct tape to one of the Plexiglas plates (check the orientation when you do this so the holes match up when the plates are overlapped to form the loop). I then added an extra layer of insulation made from polyester film to the capacitor section using carpet tape. The polyester was obtained from a transparency commonly used for overhead projection. The end without the holes can now be hinged. Make sure the duct tape is not twisted and then make a hinge with a couple of strips of packing tape to join the ends of the loop and form the hinge for the variable capacitor. The tuner is made by passing a piece of small shock cord through the tubing and through the holes in the capacitor plates.

Stretch the shock cord so that it is under tension with a knot on each end of the tuning mechanism. See Photo No. 2 for details. The capacitance can now be varied by screwing the tubing in and out which pushes the movable plate away from the stationary one. The shock cord pulls the plates together when the tubing is unscrewed and also allows the tuning screw to be removed for storing the antenna while holding everything together to avoid losing the screw. A note of caution here, even at low transmitted power there is very high voltage present on the capacitor when tuning so be sure to use plastic parts in the construction, and avoid contacting the metal surfaces of the loop when power is on. It is best if the duct tape is insulated on both sides which can be easily done by covering it with a long plastic sheath. A good source for such a thing is the material used for forming plastic bags with a heat sealer. It comes in rolls and in vari-

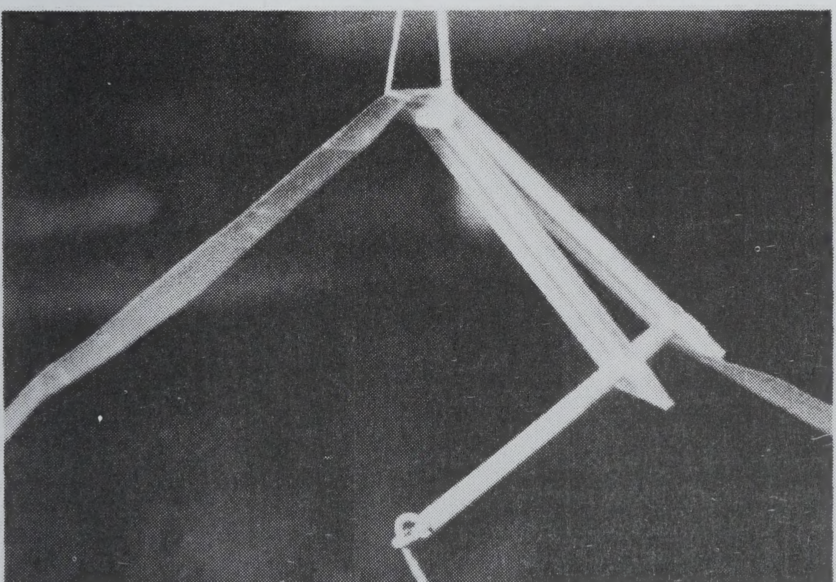


Photo 2. Tuning capacitor and top support detail.

ous widths. A width slightly wider than the duct tape is ideal and can even be sealed at both ends using a small home baggie sealer to waterproof the antenna. Alternatively a long strip of plastic can be cut from a roll of plastic sheet and folded around the duct tape and held on with strips of packing tape to achieve the same purpose.

The antenna is hung in a diamond shape which requires only one vertical support. It is important that the hinge of the capacitor be at the apex of the diamond otherwise it will not be possible to get a perfect 1:1 match to the feedline. I cut some plastic tubing slightly longer than the width of the duct tape and secured four of these to the inside surface of the loop with a strip of packing tape so that a string may be passed through the tubing for the purpose of supporting the antenna. The tubing ensures that the duct tape is not damaged by the string when the loop is put under tension. The matching section is made by cutting a piece of insulated solid wire, I used 20 gauge, to a length which is 1/5 the circumference of the loop. Solder one end of this wire to the braid of the coax and the other end to the center conductor. Ground radials are optional but increase efficiency because they double the effective area of the loop raising the radiation resistance and helping increase the bandwidth as well. I used four lengths of 24 gauge speaker wire cut to the same length as the antenna circumference and then pulled them apart to form 8 radials. Solder these to the braid as well and insulate these connections with heatshrink and electrical tape.

Erecting the antenna is a matter of finding a suitable support, trees are perfect for this. Keep away from large metallic objects as much as possible. Directly below the support point drive a tent peg to secure the bottom of the loop. An equal distance on either side of this peg drive another so that you have three pegs in line. Hook the string at the bottom of the loop to the middle peg and raise the loop by a string to the support point, then tension the

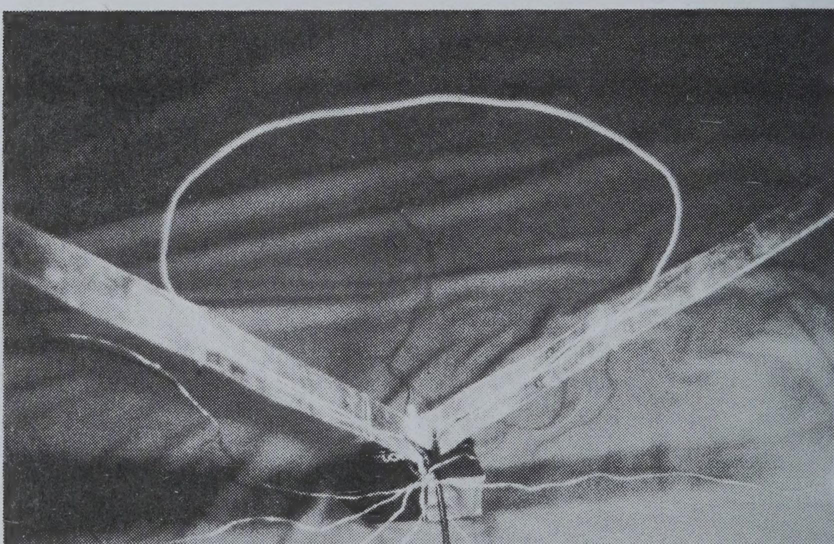


Photo 3: Feedpoint and Matching Point Detail

side lines so that you get a symmetrical diamond shape with the largest possible area. Now the matching section can be attached. Bend it into a small loop shape and secure it to the inside surface of the vee formed at the bottom of the loop as shown in Photo 3. This can be done with paper clips or hairpins or whatever works. I use some small pieces of the same insulated 20 gauge wire used in the matching section for this job, and they also double as twist ties for the ground radials which I roll up separately to keep them from getting tangled. Spread out the ground radials if any, and you are ready to tune the loop.

The antenna should be tuned at a low power. I use 1/4 watt and slowly adjust the plastic tuning screw until the reflected power drops to zero. The capacitance effect of your hand in proximity to the loop will affect its resonance. When you withdraw your hand the SWR will increase. To compensate for this find the null and then tweak the screw a little to increase the capacitance (back the threads out slightly to bring the plates slightly closer) and when you remove your hand the SWR will drop to a perfect match. Its really easy to get the hang of this after a few tries. Be sure not to touch any part of the loop while doing this since it will severely affect the tuning and could give you a shock if the loop is not fully insulated. If the reflected power cannot be brought to zero, check that the antenna is straight and symmetrical. It is important that it be erected perpendicular to the ground plane, so make sure it is not leaning on an angle. Also, you will have to experiment to see how much of the matching loop should be secured to the main loop to get a perfect match by trial and error but it can be found quite easily and is not super critical. I tune mine up for the center of the band and achieve less than 1.15:1 SWR over the entire 50 Khz tuning range. I have not tested the maximum power handling of this kind of antenna but have used up to 10 watts with no problem. When there is a wind the duct tape can sometimes flutter, which causes the SWR to flutter as well. To eliminate this problem simply lift the two pegs that guy the sides of the loop and swing the loop

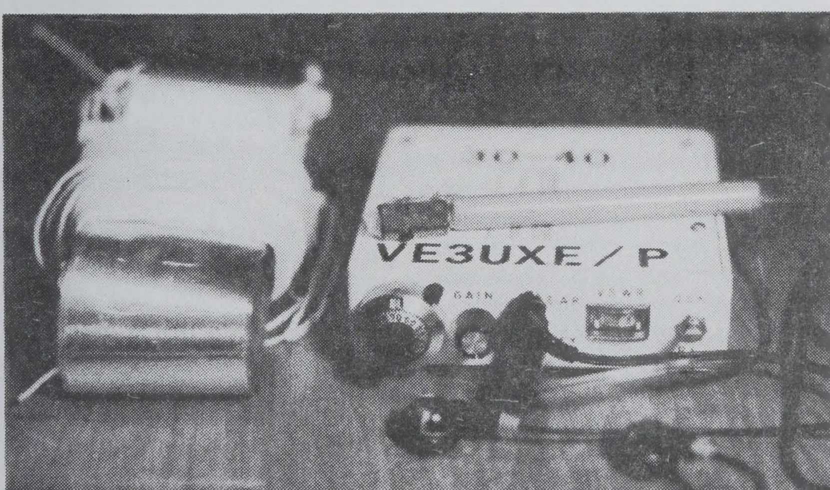


Photo 4: The complete VE3UXE Portable QRP Station.

around in the azimuth until it is lined up with the wind direction. I have also added four more support points to the loop to allow it to be spread out into an octagon shape. This is practical if there are two trees on either side of the antenna, and helps a lot to stabilize the loop against the wind.

With the materials on hand, and a little experience you can build one of these antennas in under an hour. Similarly it takes about ten minutes to set one of these up and tune it once you know what you're doing, and it works just great. I have had no trouble making many contacts throughout the continent with one watt on 30 meters. Much time and aggravation is saved in getting the station on the air with this antenna whether on the side of a clearing or in dense bush.

Build A "Jersey Fireball 40" QRP Transmitter & Amplifier

by George Heron, N2APB

The Jersey Fireball 40 isn't going to get you any trophies in the DX contests, any pelts in the Fox hunts, or any ooh's & aah's in the "bells and whistles" category of equipment in your shack ... but this little gem will go together quickly and provide all sorts of amazing contacts for you. See how many miles-per-watt you can get with just a 9V battery and antenna!

Okay, so just what is the "FB40"?

The "Jersey Fireball 40"[1] is a simple, easy-to-build low-power CW transmitter designed to operate in one of several amateur radio bands. Its name is derived from the fact that the project was designed and kitted[2] by the New Jersey QRP Club[3] members, and that the basic RF power output can be up to 40 milliwatts.

The FB40 uses a TTL crystal oscillator "can" as the heart of a milliwatt-level CW transmitter. The designer of our club project, Clark Fishman[4], WA2UNN, chose an oscillator frequency of 28.322 MHz as a starting point, added some simple circuits to divide this frequency down to hit 80m, 40m, 20m as well as 10m. We also put a low pass filter in the design to clean up all the ratty harmonics coming from the square waves of the ICs and to allow multi-band operation.

You get to select what band in which you want to operate! All you need to do is install a capacitor in the correct position on the printed circuit board to select one of the following frequencies: 28.322 MHz, 14.161 MHz, 7.080 MHz, or 3.540 MHz. The kit comes with filter components for 7.080 operation, but we supply a list of filter component values that can be used to put the transmitter on the other frequencies as well ... just substitute a couple of parts from your junk box and you'll be able to operate on 10m, 20m and 80m in addition to the 40m band supplied.

The design also includes a TiCK keyer chip! This is a small IC programmed as a fully-featured iambic keyer, including speed control and other options. All you need to do is drop this chip into the board, add a couple of components and you'll be paddling to your heart's content. (The TiCK chip is available from Embedded Research.[5])

If you add just a few more optional "T-R switch" components, you'll be able to allow an external receiver to be connected to the circuit board, thus providing transmit/receive switching using the same antenna connected to the FB40 transmitter.

And yet another option that should thrill many hams is that the FB40 design (and circuit board) includes an RF power amplifier! Once you get expert at making

contacts at low milliwatt levels, you might want to add some parts from your junk box to boost the FB40's output power to around 1.5 watts.

The Jersey Fireball 40 is quite a feature-packed little project that should provide lots of fun and many contacts.

A Little History

The "fireball" transmitter concept has been around for a number of years and has been published by several individuals. Most of these designs, including our Jersey version, are based on the use of a prepackaged oscillator contained in a metal "can" which is able to be plugged into a standard 14-pin IC socket. These cans are typically used in computers, test equipment and other devices as a source of a stable and accurate master frequency.

Oscillator cans come at various factory-prepared frequencies like 4 MHz, 10 MHz, 40 MHz, etc. However, designers are able to order the cans at specific frequencies they might need for their projects. Our FB40 oscillator frequency was chosen because it was readily available and its 28.322 MHz base frequency divides down relatively nicely into the amateur bands.

Prior articles concerning the use of oscillator cans appeared in Nov 1990 of *73*, April 1993 of *QRP Quarterly,* and Nov 1998 of *73*. You could reference these articles for additional background and use.

Circuit Description

Refer to the schematic shown in Figure 1 of the center foldout. The heart of the Jersey Fireball 40 QRPp Transmitter is a pre-packaged TTL oscillator can in the form factor of a 14-pin IC. This oscillator operates at 28.322000 MHz and swings about 1.5 Vp-p.

The basic principle of operation is that the oscillator U1 provides a signal to a series of TTL flip-flop stages used to successively divide the frequency in half. These signals are then routed through a capacitor and on to a 5-element low pass filter. The LPF provides appropriate filtering and conditioning of the original square wave signal, thus turning it into a relatively clean transmitted signal.

The divider circuits are 74LS74N dual edge-triggered TTL flip-flops, selected for their low price and low power consumption.[6] They are configured as toggle flip-flops - meaning that the output changes state on the positive edge of each input clock signal. This is ideal for a divide-by-two function desired for the FB40, knocking the 10m frequency down by half each time we add another gate. The chips operate to well over 30 MHz, so there was little problem with response, delays or signal levels.

The first stage flip-flop (U2a) after the oscillator divides the 28.322 MHz signal in half to yield a 14.161 MHz signal. The second stage U2b divides the 14.161 MHz signal down to 7.080 MHz. And the third stage (U3a) divides the 7.080 MHz signal in half to 3.540 MHz. Admittedly, the specific frequencies are not necessarily hot beds of CW activity (except perhaps on 80m), but they are not too far off the beaten path. Additionally, other oscillators can easily be substituted to achieve better/different frequencies through the divider chain.

The outputs of the flip-flop stages, and the original 28.322 MHz signal itself, are all routed to some jumper pads where you can select which signal is presented onward to the next stage by proper placement of the capacitor Cx. The 40 meter version needs to have the capacitor in the third position, allowing the 40m signal to pass on to the low pass output filter.

The output filter is a 5-element Chebychev filter with components determined by using Wes Hayward's popular

RF Analysis software programs[7]. A table of values is shown below:

	C4	L1	C6	L2	C5
80m	1700 pF	2.17 uH	2400 pF	2.17uH	1700 pF
40m	820 pF	1.1 uH	1000 pF	1.1uH	820 pF
20m	450 pF	0.6 uH	630 pF	0.6 uH	450 pF
10m	230 pF	0.3 uH	330 pF	0.3uH	230 pF

Table 1: Output Filter Component Values

The filter inductors are constructed by winding toroids to achieve the desired values. The standard formula for the number of turns was obtained from Paul Harden's, NA5N "Data Book for Homebrewers and QRPers" (see reference at end of document[1]):

N = 100 * SQRT (Ldesired / AL)

So with 1.1 uH being the desired inductance, we need about 16 turns for 40m operation.[2] If you'd like to operate the FB40 on 80m, 20m or 10m (which would be really nice in the coming sunspot peak!), just substitute the appropriate caps and inductance (# turns) per Table 1 above.[3]

The output of the FB40 was measured using an HP spectrum analyzer. The second harmonic of the fundamental 40m signal was seen at 45 dB, and the third was seen at 52 dB … not to shabby for a TTL oscillator can, some divider chips and a simple filter. And certainly good enough for safe operation at these power levels.

The FB40 is keyed by bringing the pin 7 of the TTL oscillator to ground at the KEY connector pad on the left side of the board.

The output of the FB40 was measured at 10 dBm, which corresponds to 10 milliwatts into a 50 ohm load. This varied from unit to unit and tended to be a function of how strong the TTL totem pole outputs were in the 74LS74 chips. (They aren't optimally made to be looking at 50 ohms, so the interface to the output filter isn't quite ideal.) But even so, with almost no insertion loss, the filter takes the signal and presents it effectively to a 50 ohm load, such as a tuned antenna feedline or an ATU.

The power source input to the FB40 board can be any voltage in the range of 9-14 volts. The LM78L05Z three terminal regulator can supply 5V at 100ma safely, and this circuit design operates well within that limit.

Optional Circuit: T-R Switch

When operating a separate transmitter and receiver, it is oftentimes convenient to automatically switch the single antenna from the receiver to the transmitter during "key down" times. This transmit-receive switchover can be done by several means; circuit traces are included on the FB40 pc board to provide a simple version of T-R switching.

The T-R switch function is provided by a series resonant circuit connected between the RF source and an associated receiver. Capacitor C16 and inductor L6 are series resonant at 7 MHz and provide very little signal attenuation during receive. However when the transmitter is putting out its 5-40 mW signal, diodes D1 and D2 alternately conduct, bringing the junction of L6/C16 to near ground potential during transmit. This action limits the power going to the receiver input to only about 1 mW, and makes C16 effectively part of the output filter network. Most receivers should be fine with this configuration, although its automatic gain control (agc) system needs to have fast recovery. (The agc can be adjusted on many receivers.)

Side note: The series-resonant circuit going to the receiver is a critical element, and requires some different component values when used on the various bands of the FB40. Table 2 shows the component values for the different bands of operation:

Band	C16	L6
80m	56 pF	36 uH, 9T #28 wire on T50-2
40m	47 pF	10.8 uH, 52T #26 wire on T37-2
20m	33 pF	3.9 uH, 31T #28 wire on T37-2
10m	22 pF	1.4 uH, 19T #28 wire on T37-2

Table 2: T-R Component Values

Optional Circuit: TiCK Iambic Keyer

The IC at U4 is a versatile little iambic keyer chip in an 8-pin package provided by Embedded Research (see reference at end.) This chip is not part of the components supplied in the FB40 kit, but the pc pads and traces have been provided on the board to allow you to easily add the keyer option to the basic kit. The TiCK enables you to connect a paddle to the DIT and DAH input pins, and key the transmitter through a 2N2222A driver transistor. The TiCK can be programmed by grounding the PGM connector pad at the bottom of the pc board, per the instructions provided by the vendor. Speed, memory, weighting are all controllable parameters for this chip.

Optional Circuit: RF Power Amplifier

A number of years ago, Wes Hayward, W7ZOI had published an inspirational transmitter project called the Ugly Weekender[1]. He provided some "boots" for a 4 mW flea power VFO and buffer amp such that he could bring the output power up to several watts.[2] With Wes' permission, the FB40 also provides this circuit design as an optional amplifier that the user can easily construct right on the pcb.

The amplifier is a fairly efficient Class C design consisting of driver transistor Q3 and power transistor Q4. Resistors R6 and R7 reduce the FB40's output by half so as not to overdrive the amplifier. (A 100 ohm potentiometer could be conveniently added here as a drive control.) In order to reduce the current drain of the Q3 driver transistor stage, transistor Q2 supplies +V only when the oscillator is keyed. D3 is a Zener diode used to protect power transistor Q4 in case the transmitter is keyed without an antenna connected; and C15 is used to create a total capacitance of 450 pF at the Q4 collector, including the capacitance of the transistor, the Zener, the receiver pick-off cap and the fixed cap itself. (A variable cap could be used for C15 in order to peak transmitter efficiency.) A 50-ohm input / 50-ohm output network is also used and is shown with component values are shown for 40 meter operation. (Components for operation on other bands may be determined by consulting the ARRL Handbook.) Similar to the T-R switching used with the stock version of the FB40, this amplifier uses a series-resonant L/C circuit to connect to the receiver's antenna terminal. [Note: Only one T-R switching circuit is needed – if the power amplifier and its T-R switch components are employed, components L6/C7/D1/D2 are not needed.]

Many thanks to W7ZOI and W7EL for providing a circuit to give us a signal with just a little more respect on the air!

Building the Kit

This section describes how to put

your kit together. As you progress through each step, be sure to put a checkmark in the boxes to help you keep track of things during the interruptions (phone calls, kids pulling at the sleeves, dog biting your slippers, rare DX coming from the rig's speaker, etc.)

Wind the Filter Inductors

Now comes the real fun part of the project ... the dreaded ***toroid winding exercise***! You need to create two inductors, L1 and L2, for the low pass filter. It's really not that tough. Uncoil the red magnet wire and cut in half - you should end up with two pieces each about 12" long.

Both inductors will be constructed exactly the same way by wrapping 16 turns of the magnet wire around a toroid core. Count one turn each time the wire is passed through the core.

The heat strippable magnetic wire being used requires no scraping to clear the red insulation off the leads being soldered to the PCB pads. Once the wires of each inductor are trimmed to the right length (determined by temporarily inserting them on-end into position L1 and L2 on the board), tin the ends of the wires by doing the following. Using a good hot soldering iron, place the tip under the end of the wire to be tinned and add a little solder so that there is a small pool of molten solder and flux on top of the iron with the wire in the pool. After several seconds, the insulation will melt away and the wire will be tinned where it is in contact with the iron. Continue moving the iron slowly toward the toroid core adding solder as you go, until the wire is tinned within 1/16 inch or so of the core. Repeat the procedure for the other leads and brush off any carbon residue from the ends of the wires before you insert L1 and L2 into position on the circuit board.

Tug the wires gently from the bottom of the board to ensure that the toroids are securely in place and then solder the wires to the pads.

Winding the Amplifier Filter Inductors

For the amplifier circuitry, you next need to create four toroid inductors: L3, L4, L5 and L6, and two transformers T1 and T2. Toroid inductors really not that tough to construct, and transformers are merely toroids with two windings on them!. Uncoil the supplied red magnet wire and use the specified lengths for each of the inductors as described below.

L4 & L5: Both of these inductors will be constructed exactly the same way by wrapping 20 turns of the magnet wire around a T37-6 toroid core (yellow). Measure off a 15 inch length of magnet wire and begin winding the toroid core. Count one turn each time the wire is passed through the core.

L3: Measure off a 12-inch length of magnet wire and wind 10 turns on an FT37-43 toroid core (black/unpainted), similarly to the way L4 and L5 were shown.

L6: You should next create inductor L6 in the same manner. Measure off 28" of red magnet wire and wind 52 turns around a T37-2 toroid core (red). That's a lot of turns for such a small toroid so you will need to keep the windings very closely spaced. In fact, there will be a need to overlap some of the winding at the end in order to get all turns on. That's okay.

T1 & T2: These transformers are each "bi-filar-wound" inductors on a toriod core, meaning that you'll be combining two magnet wires together and winding them at the same time. T1 and T2 are constructed identically. Measure off two 9-inch pieces of red magnet wire. These wires should be twisted tightly together as illustrated below.

(Suggestion: You can clamp the ends of the wires in a vise and use a twist drill

to wind the length of the wires together.) You will then wind the combined, twisted wire pair around a FT37-43 toroid core (black/unpainted) in the same manner as previously. See the diagram below for proper connection of the four leads:

When two wires of the same color are twisted and wound together on a toroid, it's very hard to know which ends to connect together for the center tap of the transformer. You will need to use an ohmmeter to determine proper ends. On one of the wires, a is the start and a' is the end. On the other wire, b is the start and b' is the end. You should twist wires a' and b together to form the center tap.

Trim the leads to the correct length, prepare the ends with the soldering iron again, and install them onto the board. Prepare and install the second transformer in the same manner.

Power transistor Q4 should have a heatsink, as it will be getting fairly warm during normal operation.

Provisions have been made to have the KEY pad by the U1 oscillator can also key the first stage of the power amplifier. Because this KEY line floats at 5 volts when not keyed, a Zener diode (D5) is used to prevent the 2N2222A first stage of the amplifier from being turned on all the time. This is a nice feature when operating from the firls with limited battery supply.

You should ensure that this amplifier stage is indeed OFF when the key is up ... measure the collector of Q2 to ensure that it is near zero volts with the key up. (The collector is at the junction of C7, R12 and C11 on the board.) If Q2 is not turned off, you may need to lower the value of R4 slightly until Q2 does turn off when the oscillator is unkeyed. No harm is done if Q2 is always ON, and normal operation of the amplifier is permitted; but power consumption will be slightly higher.

An interesting feature of the FB40 design and circuit board layout is that this power amplifier can be quite independent from the FB40 transmitter. The components and ground plane are layed out such that the amplifier portion of the board may be cut off in order to form a general purpose amplifier for the bench or other projects. If this is desired, merely saw the board at the marks provided on the component side. Extra pads for input, +V and ground have been provided if you do take this "standalone" route.

Optional Installation of a TiCK Keyer

Installing the TiCK keyer chip from Embedded Research makes operating a CW transmitter so much more fun. Costing only about $5, this little 8-pin IC will enable you to use your Bencher, NorCal, or whatever kind of paddles you might happen to own.

The sidetone output of the board can be used to feed an audio amplifier or a small speaker, providing a tone whenever the DIT or DAH paddle input is grounded. Alternatively, a small piezo electric speaker[1] may be conveniently driven by U4 pin 3, connected in place of R1 and R2.

A pushbutton may be connected from the PGM connector pad to ground, allowing the TiCK to be programmed in the manner described in its data sheets. The paddle connections are made to the connector pads DIT, DAH and GND.

Putting the FB40 on the Air

Connect a 50-ohm 40 meter antenna to ANT and GND.

If the T-R switching components are installed, connect your receiver antenna terminals to RX and GND. Otherwise, do not connect the FB40 transmitter directly to the same antenna as is feeding the receiver (or transceiver in receive mode). You will likely damage the receiver. If you only have

one antenna to use for both transmit and receive, and if you do not have the T-R switching components installed on the board, you could put a SPDT toggle switch in to alternately connect the antenna between the transmitter and receiver, thus providing a manual T-R switch.

If you have the amplifier side of the board populated, you'll be using the ANT and RX connections. Using the amplifier also includes the T-R switching components, so you can feel safe in connecting your receiver to RX.

Connect a hand key (or a temporary jumper) between KEY and GND. Or, if you are using the TiCK keyer, connect a paddle to Dit, Dah and Ground.

Apply power to the +V and GND and go through some preliminary checks to ensure that there are no shorts. Check for 5V to the ICs and ensure that the voltage regulator VR1 isn't getting too warm. If either condition is not right, go back and look for the solder bridges and proper placement of components. The total current being supplied should be less than 100ma.

With a receiver tuned close to 7.080 MHz, you should hear the Fireball 40 signal. The tone should be steady and free of any hash-like interference.

With a 4-to-40 mW FB40 QRPp signal driving the amplifier portion, you will have 1-3 watts going up to your antenna.

That's it! You can mount your Jersey Fireball 40 in a suitable enclosure, or just have it sitting out on the desk. Several of us in the NJ-QRP Club have put the FB40 into Altoids tins .... It's amazing how the size of the PCB worked out just right for that.

Go forth and communicate!

[1] For a short time, this piezo device is available free from Embedded Research with the purchase of a TiCK keyer chip.

NOTES:

1 The "Jersey Fireball 40 QRPp Transmitter" is copyright 1998/1999 by C. Fishman and G. Heron. All rights reserved

2 NJ-QRP Club is selling the basic 40m kit of parts and pc board for $10 postpaid. Write to NJ-QRP Club, George Heron, N2APB, 45 Fieldstone Trail, Sparta, NJ 07871.

Website: http://www.njqrp.org
E-mail n2apb@amsat.org

3 The New Jersey QRP Club is a group of amateurs located in-or-around New Jersey with a common interest of low power communications, efficient operating skills, and a love for homebrewing of electronic equipment. Membership is free. Monthly meetings are held near Princeton. Club members are in regular contact via an Internet mail listserver. To subscribe, put SUBSCRIBE NJQRP in the body of an e-mail and send to
LISTSERV@NJQRP.ORG.
A comprehensive and fun club website is regularly maintained at
http://www.njqrp.org.

4 Clark Fishman, WA2UNN, PO Box 150, Andover, NJ 07821. E-mail: wa2unn@nac.net

5 Embedded Research (supplier of the TiCK keyer chip), PO Box 92492, Rochester, NY 14692. E-mail: http://www.frontiernet.net/~embres/

6 By using "Advanced CMOS" TTL devices instead of the "Low-power Schottky" ones used for U2 and U3 (74LS74), one could get more effective power transfer from the chips. The AC devices provide an output impedance much closer to the 50-ohms that the output filter was designed

for, thus providing a better match and more power to the antenna work using the FB40 on 20m through 80m.

7 Some builders have questioned how we obtained the output filter component values for operation on the different bands. The computer program used is one called "L.exe - Low Pass / High Pass Filters, version 1.50", a Wes Hayward program supplied by the ARRL. This is a neat program that automates one of the standard filter calculations in the Handbook to provide all sorts of filters with varying parameters: Butterworth, Chebyshev, Elliptical, variable number of elements, cut-off frequencies, and maximum ripple values. In each case, we chose a 5-element Chebyshev low pass filter with 50-ohm input and output impedance, with 1 dB maximum ripple, and a cut-off frequency at the next higher megahertz value from where we were operating. [e.g., a cut-off frequency of 4 MHz was selected for the 80m filter, etc.]

8 Paul Harden's, NA5N, excellent reference book is called "Data Book for Homebrewers and QRPers", ISBN 0-913945-57-9, and costs about $20. You can contact Paul at na5n@rt66.com

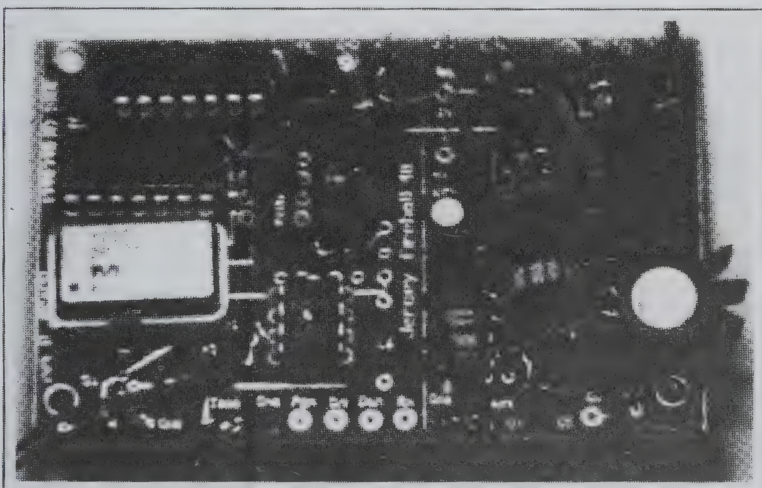
9 In order to accommodate the greatly varying core permeabilities at different frequencies of use, each core has an inductance index, or "AL". Thus looking up the T37-2 core used in the FB40, you'll find its AL = 40 uH per 100 turns. So if we wanted the 1.1uH value for our filter inductor, the equation computes to: N=100*SQRT(1.1/40)=16.58. Since we can't have fractional windings with toroidal inductors, we rounded this to 16 Turns. Close enough!

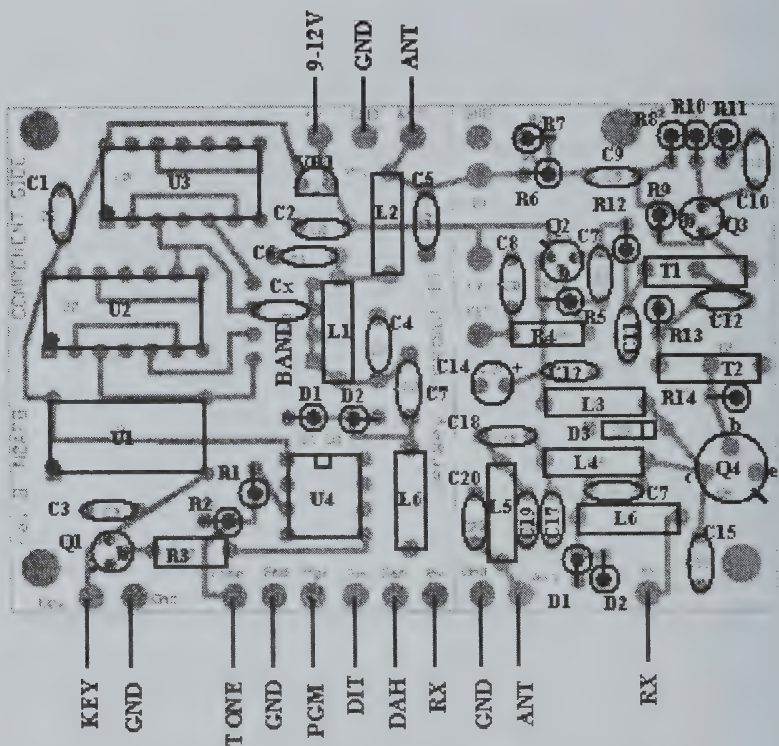
10 You might need better quality capacitors when attempting to build your output filters for the higher frequencies. At 14 MHz and 28 MHz, the el cheapo disc capacitors are quite lossy and results in a low Q filter. Try using some silver mica caps (or equivalent) and your output power at the higher frequencies might improve.

11 W7ZOI's Ugly Weekender was published in QST for August 1981

12 Wes had also based this amplifier directly on the work on Roy Lewallen, W7EL, in a project Roy did called "An Optimized QRP Transceiver" in QST for August 1980.)

13 For a short time, this piezo device is available free from Embedded Research with the purchase of a TiCK keyer chip.





Component layout for New Jersey Fireball 40 & Amp

The St. Louis Doublet

by Dave Gauding, NF0R
nf0r@slacc.com

The St. Louis Doublet is a lightweight 10-40M antenna for portable or fixed locations. The SLD uses a South Bend SD-20 collapsible fiberglass fishing pole as a single support. This design borrows gently from the classic G5RV antenna of Louis Varney. An SLD is usable with manual or automatic antenna tuners. With feedline shorted and worked against a good ground the doublet will also operate 80M. The popular 20' fiberglass pole is prone to bending along the slim 3' tip section. Keeping the overhead weight, sail area and feedpoint movement under control prompted this project.

Parts List

1 ea. #01 safety fishing swivel
6 ea. small nylon tie wraps
1 ea. 1/4" phone plug shell
1 ea. BNC bulkhead jack
18' flat computer cable, 2 conductors
51' #20 magnet wire
CA-type instant cement
Silicone sealant/adhesive

Assembly

1. Following the example thread the flat computer cable feedline through the lower eye of the swivel leaving two inches protruding. Fix in place by adding tie-wrap immediately above the lower eye.

2. Now thread two tie-wraps through the lower eye. Cinch-up to approximately the size shown in the example. These are the insulated points for the radiator elements.

3. Cut the magnet wire into two 26' sections. Strip the ends and attach to the tie-wraps. Leave a pigtail for connecting the radiator to the feedline.

4. Split the computer cable about one inch above the swivel. Strip the ends of both stranded conductors. Position the conductors along the radiators and wrap with the pigtails. Solder the connections.

5. Use a tapered reamer to open the end of the phone plug shell to take the threaded body of the BNC jack. Turn down flush several times to establish the threads in the plastic. This assembly provides the transition from flat cable to the coax.

6. Split and strip the lower end of the flat cable. Then slide on the phone plug shell. Solder one conductor to the BNC center-pin. Solder the other conductor to the anti-turn flat machined in the jack threads.

7. To achieve a good joint with minimum solder accumulation file the flat down to bright metal before soldering. If necessary file the joint flush after soldering to aid in fitting the plastic shell to the connector.

8. Add three tie-wraps along the flat cable feedline covered by the phone plug shell. The assembly will be potted. These tie-wraps serve as strain reliefs for the soldered connections.

9. Carefully thread the previously installed plastic shell past the wiring connections and then screw on to the BNC connector. Add a CA cement seal before mating the two parts permanently. Allow this joint to dry thoroughly before potting the assembly.

10. Fill the shell to the top with silicone sealant. Center the feedline in the shell and allow the assembly to dry for twenty-four hours.

Builder Notes

#20 magnet wire is the heaviest size recommended for this particular doublet when suspended from the SD-20 pole. #26 magnet wire is very serviceable and will survive all but the strongest winds. Any solid or stranded wire of equivalent weight including insulated wire may be substituted. Since magnet wire is usually soft drawn it makes sense to convert to hard drawn to avoid sagging and dimensional changes later. Attach the wire to a solid point. Pull steadily until it stops stretching and trim to size. 51' of magnet wire can lengthen several feet.

17-18' of tuned feedline seems to work well for this application. The RG-58 feedline continuation can be any reasonable length. Since the SLD is tuned remotely the feedline dimensions and impedance are not that critical. No follow-up work has been done to optimize performance such as adding a coaxial balun.

The unbalanced configuration makes the antenna usable with automatic as well as manual antenna tuners. A continuous flat cable feedline can be used if a balun is available. Precautions must be taken to protect the fragile stranded wire connections.

A smaller #03 swivel can be substi-

tuted for size #01. A little more dexterity is required during fabrication. Either swivel size slips through the convenient wire eye at the tip of the SD-20 pole. The element ends can be looped to create a low-profile attachment point or collar buttons are good lightweight end insulators. Inexpensive solid monofilament is the preferred support line.

The choice of potting material is not critical. Any high-quality silicone adhesive is acceptable. Epoxy glue is a suitable substitute.

Related Antenna Applications

Either size fishing swivel can be used for tuned doublets fed with 300 ohm twinlead. Cut a 1/4" long opening about 2" from the end of the line. Position the opening over the lower eye of the swivel. Attach each side of the feedline by passing a tie-wrap through the eye. Strip and trim the excess wire and solder to the radiators. Stronger radiator wire may be required for antennas with long unsupported runs of twinlead. The homebrew connector for transitioning from tuned flat cable to coax is usable with 300 ohm twinlead as specified for the original G5RV antenna. Punch several clean holes through the webbing so the potting material can get a good grip on the feedline. Epoxy glue is recommended for potting this modification.

On the Air

The prototype SLD was routinely tested at one watt output on 10, 15, 20, 30 and 40M for several weeks. The antenna was installed on a SD-20 at 20' and configured as a shallow inverted vee. On 80M it was fed against a cold water pipe ground. The SLD's overall performance justifies passing the design along to others.

Even with several sharp bends at the feedpoint the flat cable handles 50W output consistently without complaint. This was the maximum output available during testing.

The flat cable should be taped about 2' below the SD-20 tip during installation. This distributes overhead weight more effectively and helps the tip section resist bending in stronger winds. When installing an SLD balance the elements so there is no side pressure on the pole other than the basic weight of the antenna. Wrapping the feedline several times along the SD-20 support reduces sail area.

The simplest way to mount an SD-20 pole is to slip it over a 1.25" diameter hardwood dowel. Drill a 12" dowel to take a sturdy 10" steel gutter spike. Rest the pole butt right on the ground or on three pan-head screws installed equidistant near the bottom of the dowel. Longer dowels may be used to elevate the feedpoint several more feet.

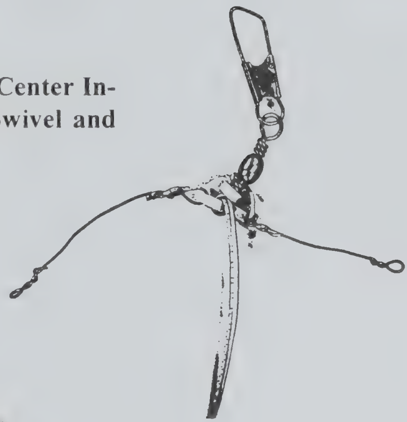
Reality Check

The flat computer cable feedline is undoubtedly lossier than traditional twinlead, 450 ohm and 600 ohm alternatives. However, other than #24 gauge speaker wire or RG-174 coax there are few truly lightweight feedline alternatives for horizontal antennas suspended from an SD-20 pole. With the forgoing in mind convenience gets the nod over maximum performance with an SLD. On the plus side the antenna installs quickly practically anywhere and does not require ground radials. This is a very serviceable doublet for the minimalist operator with emphasis on portable operations..

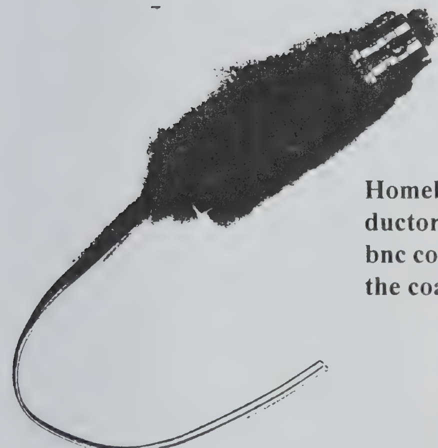
Comments

A follow-up to the St. Louis Doublet will describe a 10-80M version along with the companion St. Louis Shaft. The latter is a simple a low-cost pvc upright for elevating the feedpoint up to 40' high. Builders spending a pleasant hour at the bench

and a $5.00 bill will not be disappointed with the performance of an SLD. As always, improvements and modifications are officially encouraged.



Dave Gauding, NF0R's Center Insulator made from #3 Swivel and nylon wire ties.



Homebrew connector for twin conductor cable and coax (note that a bnc connector is used to connect to the coax)

Number 3 Fishing Swivel as it comes out of the package.

Basic 40 Meter Popcorn Superhet Receiver

by Todd Gale, VE7BPO
1436 Cherry Cresc West
Kelowna BC V1V3X8 Canada

Discussion

The Basic 40 Meter Popcorn Superhet Receiver is a no-frills, relatively low-cost superhet receiver with a 4.00 MHz Intermediate frequency. With the exception of Q6, all transistors are the ultimate popcorn part, the 2N3904. This is the basic sister to the enhanced version on this web site. Much of the design of the various stages must be credited to Wes Hayward as I borrowed heavily from his previous work and through ideas obtained by discussion. If one were to homebrew the diode ring mixers, indeed this would be a very low cost receiver giving reasonable performance which outperforms any NE602 based superhet receivers that I have built or listened to.

Bandpass Filter and RF Preamp

From the 50 ohm receiver antenna jack, first off is a double-tuned bandpass filter which was designed by Rick Campbell, KK7B and works very well. The trimmer caps can be the 5 - 20 pF units sold by Digikey and Mouser. The fixed-value caps in my prototype were inexpensive monolithic ceramic capacitors purchased from DigiKey. Rick used an NP0 ceramic for the 10 pF coupling cap plus silver-mica type for the 100 pF caps in his original design.

The RF amp is a feedback amp pulled from Solid State Design for the Radio Amateur published by the American Radio Relay League. It has a 50 ohm input to properly terminate the bandpass filter. A -6 dB pad follows the amp to help provide a 50 ohm input for the following mixer and to reduce stage gain to help preserve the signal to noise ratio of the receiver. The transformer T1 is one of 3 broadband transmission line transformers in this receiver. It transforms the 200 ohm collector impedance to 50 ohms for the following stage.

Mixer and Diplexer

A 50 ohm diode ring mixer (7dBm) such as the MiniCircuits SBL-1 or TUF-1 or homebrew are all suitable. Following the mixer is a simple diplexer using the ~3 times the IF rule that I have seen in many textbooks and articles. The cutoff frequency chosen was 11.78 MHz as this allows the use of a standard value capacitor (270pF). To wind the .68 uH inductor use 13 turns on a T37-2 toroid or 12 turns on a T50-2 powdered iron torroid core. You can easily use 24 - 26 AWG wire for the inductor. Do not omit this diplexer!

IF Preamp and Crystal Filter

Some builders may object to the choice of a 2N3904 as the IF preamp since thie transistor used should ideally have an Ft of 500 or greater. This is done in the sister receiver and the sister's huskier IF preamp can be used instead of the stage shown. A 2N5179 or PN5179 could also be substuted for the IF Preamp or RF amp transistors, if you have them on hand. The resistive pad following the IF preamp is mandatory and provides the correct 200 ohm input impedance for the crystal filter that follows.

The IF filter crystals should be closely matched in frequency to prevent unwanted ripple in the passband. Generally, you have to buy 10 and then if you have a frequency counter, use the receiver BFO stage to test your crystals for matching. Pick the closest 4 crystals and use them in your filter. It does not matter if the crystals have series or 20 pF load capacitance, but it does mat-

ter that they are matched in frequency within 40 hertz of one another or better for this receiver.

For my prototype receiver, I purchased ten 20 pF load capacitance 4 MHz crystals and luckily found 4 that matched each other within 9 hertz! For those builders who do not have a frequency counter, some QRP parts retailers sell matched sets of crystals.

It is important to note that the BFO should be set on the high side of the IF frequency as simple crystal ladder filters have a steeper upper passband than lower passband. The crystal filter is terminated by the 4:1 transmission line transformer and then 50 ohm impedance of the IF amplifier. The -3dB pad following the IF feedback amplifier also helps to terminate the crystal filter by helping ensure a 50 ohm IF amp input impedance and should not be omitted.

Many may balk at just one stage of IF amplification, but since there is no AGC and this is a CW receiver, it works well. A feedback amp is once again used to provide correct input and output impedances for stages connected to the IF amp. A simple IF gain control is used, but could be easily omitted for the more frugal builder. To do so, remove the IN4007 diode from the .1 uF cap on Q3's emitter and connect a 4.7 ohm resistor from the .1 uF cap to ground. When the 1K IF gain pot is turned down to just above minimal IF gain, some noise is generated but is easily avoided by tweaking the IF gain control. An alternate scheme could be omitting the IF gain control as discussed and replacing it with a switchable -10 dB resistor pad in the circuit.

For the IF gain control, any junkbox rectifier-type diode could be used if you do not have a 1N4007. Following the IF amp is another attenuator set for -3dB and then a 50 ohm diode ring mixer. The mixer/detector can be SBL-1 or TUF-1 types or homebrew if you want to reduce costs further as the mixers are the single most expensive components in this receiver.

AF Stages

Following the detector, a grounded base amp connected to an active decoupler is used to provide a 50 ohm, hum-resistant active termination to the product detector. No low pass filtering is used in the AF stages however audio quality and gain are good. Two high pass caps to ground are used to remove circuit hiss. The 1 uF coupling cap connected to the 10K pot was picked to attenuate any remaining power supply hum. Keep all leads short as practical in the AF preamp to help insure stability. Use a simple 10K linear-taper pot for the volume control as the 4K7 resistor gives a faux log-taper response. Q7 is completely optional and is used to mute the receiver if it is used in conjunction with a transmitter.

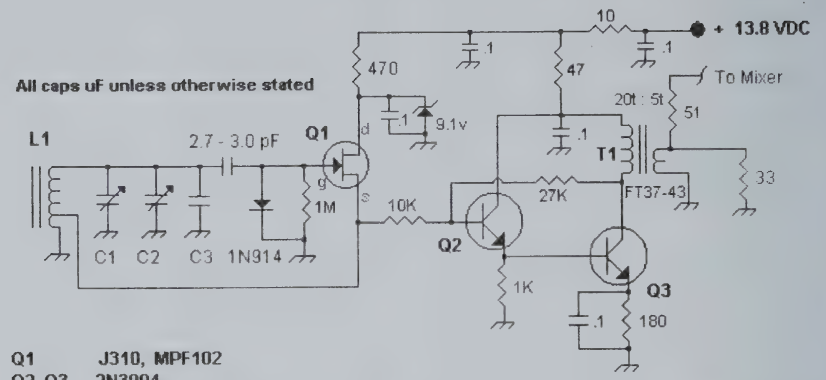
The AF amp is the perennial LM386N and is a low cost, easy to use AF amp. Turn it upside down and solder pins 2 and 4 right to your copper ground plane to anchor this part. There are a number of low-noise alternatives to the LM386 available which are generally more expensive but would be quite suitable. Discrete component AF amps can also be used, but a popcorn part such as the LM386N maybe cheaper and easier.

VFO and BFO

This VFO was first popularized by Roy Lewallen, W7EL and has been used in countless homebrew and commercially sold QRP rigs. For the 40 meter ugly superhets, you have a choice of a VFO frequency of 3 MHz or 11 MHz and I chose the former for this project.

For L1, you can use the T68-6 as shown or redesign your own inductor using a T50-6 core. The T68-6 core allows the builder to wind the coil using # 24

3 MHz VFO



Q1 J310, MPF102
Q2, Q3 2N3904
L1 44 turns T68-6 , Tap at 11 turns from grounded end

drawn 02/02/94

AWG wire for enhanced Q and stability. The main tuning capacitor, C1 that was used had a built in reduction drive and went from 4 - 19 pF. If you use a tuning capacitor with a greater capacitance swing, you may have to connect it to the top of L1 via a small-value NP0 capacitor to reduce the tuning frequency range. This can be done using math or by just plain experimentation.

C2 is a small ceramic air-variable trimmer from my junk box used to set the lower band edge of the VFO. It can be omitted if the user wants to go frugal and experimentally set the lowest frequency of the VFO using small-value ceramic NP0 caps.

Air variable caps for C1 and C2 are mandatory for minimal drift VFO operation. C3 actually refers to 4 NP0 ceramic caps which were used to place the VFO on the correct frequency. Four caps were used to minimize heating and thus drift in the VFO.

For the prototype VFO which tunes something ~ 3.00 to 3.67 MHz, I used the mentioned air-variable, four NP0 ceramic caps (20pF, 100pF, 5pF, 100pF) and C2 the trimmer cap that went from 2 - 50 pF. These values should be used only as a guide for prospective builders as there are many variables at play.

Following a 10 minute warm up period, the VF0 frequency stability is excellent. Again, keep all component leads as short as possible. T1 is a broadband transformer wound by using 20 turns of # 26 AWG over a FT37-43 toroid core and then distributing 5 secondary turns spaced evenly over the primary windings. Do not omit the 33 ohm load resistor. The 2.7 to 3.0 pF coupling cap should also be of the NP0 ceramic type. Q1 can be the J310 (my favorite) , 2N4416 , MPF102 or other correct substitutes. This VFO should be in a seperate sealed, shielded box from the rest of the receiver.

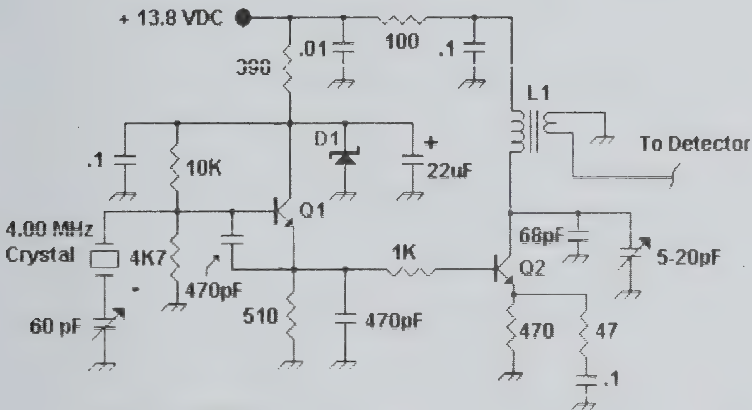
VFO Stability Hints

Numerous tips for enhancing VFO stability have been generated from Wes Hayward, W7ZOI, Roy Lewallen, W7EL, Doug DeMaw, W1FB and others. Here are a few summarized:

1. Use air wound or powdered-iron toroidal inductors made from number 6 material.
2. Use the heaviest guage of wire possible to wind your inductor.

3. Anneal the inductor by boiling it in water for around 5 minutes after winding.
4. Use ugly construction above a SINGLE-SIDED copper side up ground plane.
5. Capacitors in the L-C circuit should be NP0 ceramic type.
6. Use air variable capacitors for tuning that have double bearings and no backlash.
7. The VFO should be operated at a lower regulated voltage.
8. Do not use cheap low-Q trimmer caps.
9. Completely encase the VFO to prevent RF leakage and to minimize environmental temperature changes.

4 MHz BFO



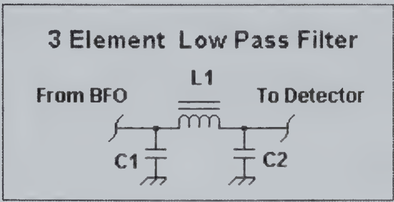
Q1, Q2 2N3904
D1 9.1 volt 400 mW Zener Diode
L1 19.8uH, XL = 498 ohms T68-2 Toroid 59t Primary 12t secondary

Shown is a 2 stage BFO for use with the ugly 40 meter superhets with a 4.00 MHz IF. This is a design by W7ZOI which I have used from 3.5 to 9 MHz by only changing the crystal and the Q2 output coil and capacitor values to suit the frequency of choice. The output coil is 59 primary and 12 secondary windings on a T68-2 toroid core. You will need in the order of 79 pF to resonate this coil, thus a 68 pF plus a 5-20 pF variable works well.

If you do not have a T68-2 core, a T50-2 could be used with 30 AWG wire which is a bit difficult so you could opt for an XL of 200 ohms which would be 40 primary and 8 secondary turns on a T50-2 core. You would need ~200 pF to resonate such a coil and the BFO would have reduced output power, but would still work okay. If you design your own tank, you probably should not use an XL/XC less than 190 ohms for the output stage at 4 MHz. Use a 5:1 turns ratio for primary to secondary windings.

It wouldn't hurt to follow the Popcorn Superhet BFO with a low pass filter. A simple pi-type 3 element filter is suitable. Since I had a couple of 470 pF caps left over, I made a low pass filter using a 6.8 MHz cutoff frequency with a 1.17 uH inductor. A 1.17 uH inductor using a T37-2 core requires 17 turns while on a T50-2 core requires 15 turns. Caps were inexpensive monolithic ceramics from DigiKey. The filter is shown below, L1 = 1.17uH , C1 and C2 = 470 pF. If you want, you may

use other cutoff frequencies to suit any junkbox caps you have on hand and use an XL/XC of 50 ohms.



BFO Construction

Keep component leads as short as possible to promote stability. Do not omit the zener diode D1. I thought of using a small ferrite bead on the base of Q2 and will try it on the next version of this BFO that I make. The BFO, if unstable can break into all sorts of weird AF sound effects that are very annoying. The BFO should ideally be in a shielded box, but many amateurs have good results by just placing the BFO strategically in the receiver chassis.

When winding L1, make sure you wind the secondary coil so that the secondary's grounded end is on the cold side of the primary coil that connects to the 100 ohm resistor and positive voltage. I just pick one end of the primary coil and close wind the secondary coil from this point in the same direction for the correct number of windings. Then the starting point of the secondary can be grounded and the other end connected to the detector or a low pass filter.

After building the coil, temporarily place a 51 ohm resistor from the secondary output lead to ground. Then you can test and peak the tuning of the output tank into a load. Leave the resistor in place for all your testing work such as crystal matching or RF stage testing until you are ready to connect it to the product detector.

The 60 pF variable cap connected between the crystal and ground is used to set the beat frequency of the BFO. Adjust it to get a good sounding beat note when listening to a station. You will notice that the beat frequency can be tuned roughly by just listening to 40 meter band noise in the headphones and then tweaked on an active QSO.

Construction Ideas

When constructing any project, build in small modules and test each one seperately. For instance, the AF amp should be built first and then tested by injecting a very low-level audio frequency tone into that stage and listening for output in your headphones. Every QRP workbench should have a simple AF tone oscillator from a schematic similar to the ones used for keying sidetones in CW transmitters. The encased oscillator should have to a 100K or so potentiometer connected to the output to vary the output signal amplitude. Generally use maximum resistance on the 100K pot to start with and reduce this resistance slowly as the in-test amplified oscillator output could be very loud!.

After testing the AF amp, build the 3rd AF preamp stage including the 10K panel mounted pot so you can vary the gain going into the AF amp. Now inject the AF oscillator output into the input on the pot and vary the 10K pot to ensure that the stage you built is working. It should be a lot louder now and should go up and down in volume with the 10K pot.

Finally build the remaining preamp stage and once again test the circuit with your AF oscillator. The output into the phones should be painfully loud now when cranked up!

The next stage to build would be the BFO. If you do not have a scope, peak the tuned circuit by watching the S meter on a radio receiver located nearby. Ensure that you put a load on the output winding of the BFO such as 47 ohm resistor to ground. A small piece of wire can be used as an

antenna if the BFO signal is too weak to activate the S meter on your receiver.

Once peaked, you can now use the BFO to match your IF crystals. To use the BFO to match your crystals, use a small wire to bypass or disconnect the 60 pF variable capacitor that is used to connect the crystal to ground. In other words, the bottom lead of the crystal is connected to ground with a short piece of wire. This makes testing your crystals a little more scientific as the variable capacitor cannot influence the crystal frequency during testing.

You can also use the BFO in conjunction with a scope or voltage probe to test the various RF amps in the receiver. I do this all the time with my scope. Proceed with this build a stage, test a stage method and you should be rewarded with a functional end product.

Uglier Sister 40 Meter Popcorn Superhet Receiver

by Todd Gale, VE7BPO
1436 Cherry Cresc West
Kelowna BC V1V3X8 Canada

[Note: Main schematic in center section]

Discussion

Above is the higher-performance big sister to the Ugly 40 Meter Popcorn Superhet. It resembles its little sister quite a bit and parts between the two designs maybe interchanged to suit the builder. Parts common to both rigs will not be discussed, please read the comments on the 40 Meter Popcorn Superhet Receiver webpage in addition to the comments on this page.

Filters and RF Amplifier

Following the bandpass filter is a Norton transformer-coupled negative feedback amplifier. This stage is designed for a gain of 12 dB, although the 9 dB gain design would also be very suitable. Please refer to the web section entitled A Low Noise Broadband RF Amp for winding instructions. Transistor choices for Q1 are any low-noise type such as the 2N3866, 2N5109, 2N5179 or PN5179.

The Norton Amplifier

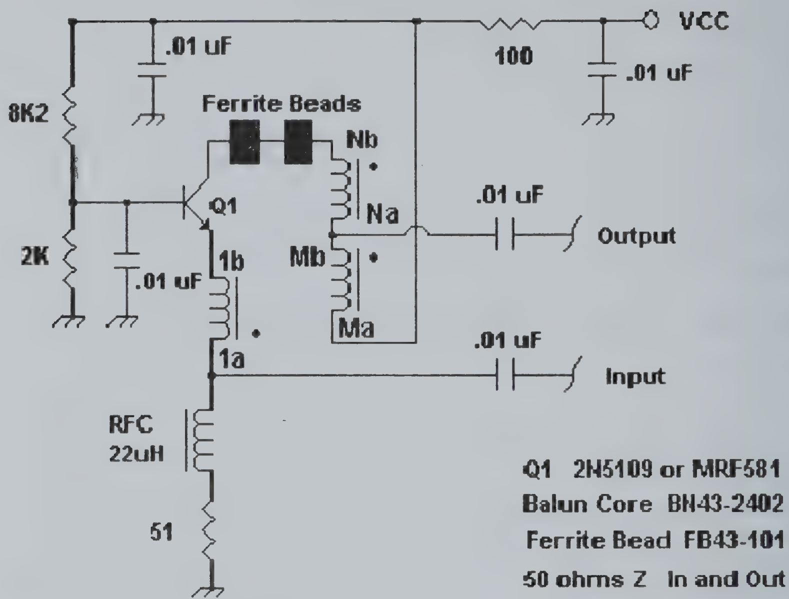
The above schematic is a version of a circuit developed and patented by David Norton and Allen Podell in June 1974. This variation was described by Joe Reisert, W1JR in the now defunct Ham Radio Magazine. The Norton design uses transformer coupling to achieve "noiseless negative feedback" and is really outstanding. A great article utilizing and augmenting on this technique receivers is by Jacob Makhinson, N6NWP in QST magazine for Feb 1993 with "A High Dynamic Range MF/HF Receiver Front End". Makhinson arranged 2 in push-pull to obtain excellent results. Obtain a back-issue of QST for closer study.

If you are building a contest-grade receiver and need a good RF preamp and/or post mixer amplifier, the Norton type is quite suitable. An amp built using a 2N5109 can have a noise figure in the 2.5 - 3dB range. I have also built them with 2N3866, MRF517, MRF581 and a 2N5179 although the last transistor would be a somewhat poorer choice. This schematic with a 2N5109 is good from 1.8 to 150 MHz with a 1.2:1 VSWR or less according to Joe Reisert. I have even put one in a friends CB radio and he was delighted.

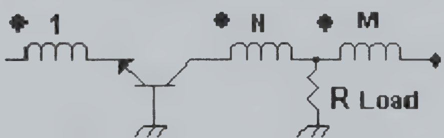
Winding and Construction Hints

Making the Norton amps requires some planning to keep all component leads as short as possible. The transistor leads

High Dynamic Range RF Amp

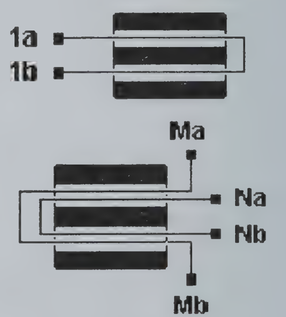


Four Practical Transformer Ratios



N = 1 , M = 2 , GAIN = 6 dB
N = 5 , M = 3 , GAIN = 9.5 dB
N = 11 , M = 4 , GAIN = 12 dB
N = 19 , M = 5 , GAIN = 14 dB

Balun Core Winding Info



and any connecting components should be trimmed as short as practical to promote stability. Sketch the component layout on a piece of paper and modify it until you are satisfied you have designed a good layout. I usually use a terminal strip piece to support the transformer and to attached the positive voltage wire to. The ferrite beads on the transistor collector aid in stability and should be used to preserve the noise figure by squashing any oscillations should they develop. The 22 uH choke can be the little epoxy coated units that are color coded and look somewhat like resistors. Do not use a choke less than 22 uH.

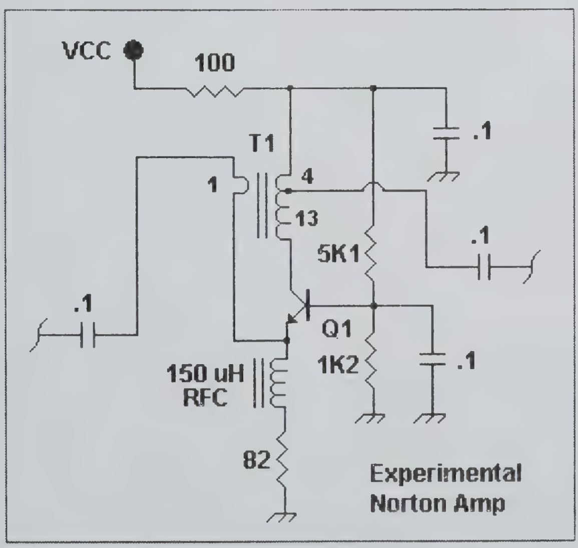
Before winding, the builder must first decide how much gain is needed from the amp. For an RF preamp, the stage should have gain equal to or greater than the passive stages after it. Also there will be losses

in the transformer, so the theoretical gain of the Norton amp maybe 1 dB off and will need to be factored in.

For the purposes of discussion, a 9.5 dB amp is desired , so N = 5 and M = 3. The first step is to mark one side of the core with a dab of liquid paper, paint or a small piece of tape. This will allow you to keep track of the transformer later. To mark, hold the core so that both channels are parallel to the floor, one on top of the other. Apply your dab of paint to the top of the core and use the marked top to denote the A windings. 1a, Ma and Na will all start from the top channel in the balun core.

Using 32 AWG wire for all three windings, start with winding 1 and wind the single turn from point 1a to 1b. Cut off the leads so thay are shorter than 2 inches. Next, wind Ma to Mb three complete turns through the binocular core and trim the leads if needed. Tie a small knot in the wire at both ends. This will clearly mark this M winding. Both windings should look like the diagram under the schematic. 1a to 1b are on the left of the balun core and winding Ma to Mb are on the right side of the core. Mb has a distingishing knot at the tip of both wire ends. Ma starts from the top of the core which you have marked with a dab of paint or something. Finally, wind Na to Nb five complete turns through the core in the same direction as the previous winding M. Strip wires Na and Mb (Mb has the knot) , twist together and solder.

Strip the leads VERY gently with sandpaper or your favorite other method. Insert the transformer in your circuit and cut the leads to their proper length and then solder away. It maybe preferable to prestrip the leads on winding 1 as it is hard to strip the enamel off a fine wire that has only one turn and it may accidentally pull out of the core. If it does, just re-insert it into the balun core on the correct side. Once you have soldered Na and Mb you can always identify the windings later because you have marked the top of the balun core which denotes the A windings. Try and make your windings gently tight as if there is too much slack you may have difficulty getting the last few windings thru the core



channels. A 14 dB gain amp maybe impossible to wind with 32 AWG wire, it may best to use 34 AWG for that amplifier. I have never built one for greater than 12 dB. The transformers are a bit tedious to wind, however persevere and the results will be well worth it. For HF, you can substitute 0.1 uF caps for the 0.01 caps shown if you like.

The amp shown in the above schematic experimentally uses a ferrite toroid for the transformer and has ~10 dB gain. Incidently, it can also be wound on a balun core using 2 windings, a one turn loop and then a second wire with a tap as shown in the above schematic. A balun core would not be experimental and this amp is very stable with a balun core.

To wind the toroidal version of this amp, wind 13 turns of AWG #26 on a FT37-43 core. Next wind the 14th loop but leave a generous loop for tapping into. Then wind 3 more close turns on the coil to finish. You should have 17 turns of wire with a tap 4 from the end, thus creating the 13 - 4 inductor as shown in the schematic. To complete the coil, wind 1 turn of wire over the cold end as shown in the schematic. It is tricky, but try to keep the one turn link as short as possible. A ferrite bead over the transistor collector is also helpful, but not mandatory. You can try increasing the turns (1:21:5 etc) to experimentally obtain more gain from this amp. The toroid version of this amp is good for understanding how the Norton amp works and maybe an option for builders who do not have balun core ferrites in their junkbox.

Mixer and Diplexer

For the mixer, a 50 ohm diode ring mixer such as the SBL-1 from Minicircuits can be used. LO injection should be around 7dBm. The diplexer that follows is described elsewhere on this website and to get the necessary 800 pF for the capacitors, simply parallel a 470 with a 330 pF or a 120 pF with a 680 pf capacitor. The inductors at 1.99 uH are wound on powdered-iron toroids. You can use # 26 AWG wire and it requires 22 turns on a T37-2 core or 20 turns on a T50-2 core. In addition, you can use a #6 material toroid or substitute the lower order diplexer from the sister 40 Meter Popcorn Superhet.

IF Preamp, Crystal Filter and IF Amp

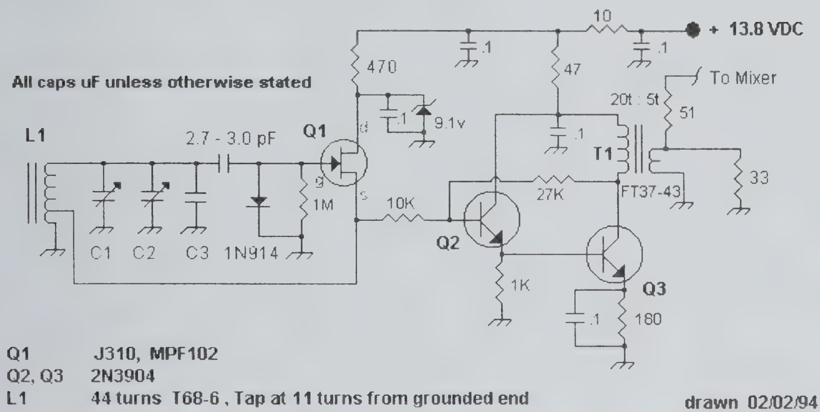
Except for the coil, the IF preamp and IF amp are identical and both warrant a small clip-on heat sink. These amps draw substantially more current than their counterparts in the sister receiver. The 200 ohm -6dB pad following the IF preamp should not be omitted as it helps prevents the stage from seeing reactances created ahead by the crystal filter. The four diodes form a 13dB limiter to protect the crystal filter should a catastrophically large signal be present in the receiver's front end. They maybe omitted. A -3dB 50 ohm resistive pad terminates the IF amp and helps establish a 50 ohm input impedance for the product detector ahead. No IF gain control is used. This receiver has good large signal handling capability and reducing the AF gain was found to be all that was needed when listening to the kilowatt crowd. An IF gain control similar to the sister receiver could be used if the IF amp emitter resistor section was redesigned. The input impedances of the two feedback RF amps is ~50 ohms. The crystal filter is unchanged from the sister receiver.

VFO and BFO

This receiver uses the same VFO/BFO as it's little sister. For improved performance, one could follow the VFO with a low pass filter to launder any harmonic energy present in the output. A low pass filter is also helpful following the BFO.

You can use the simple 3 element filter shown with the BFO schematic or design a half-wave filter if you are really keen.

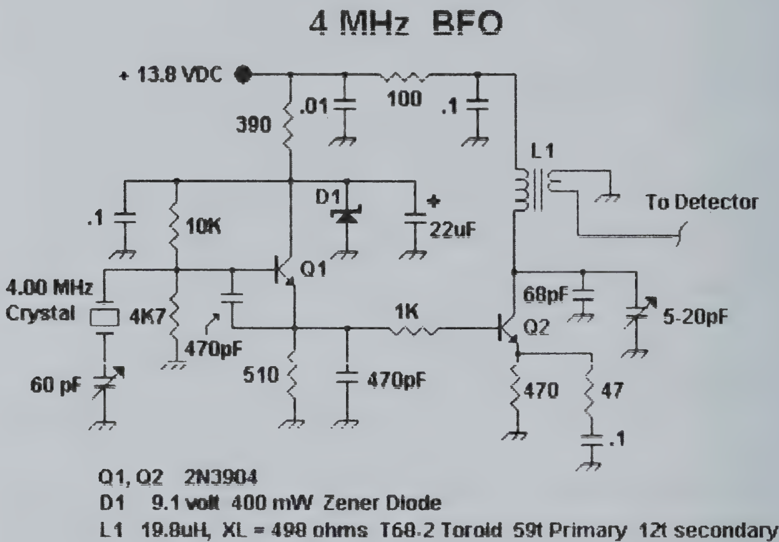
3 MHz VFO



This VFO was first popularized by Roy Lewallen, W7EL and has been used in countless homebrew and commercially sold QRP rigs. For the 40 meter ugly superhets, you have a choice of a VFO frequency of 3 MHz or 11 MHz and I chose the former for this website. For L1, you can use the T68-6 as shown or redesign your own inductor using a T50-6 core. The T68-6 core allows the builder to wind the coil using # 24 AWG wire for enhanced Q and stability. The main tuning capacitor, C1 that was used had a built in reduction drive and went from 4 - 19 pF. If you use a tuning capacitor with a greater capacitance swing, you may have to connect it to the top of L1 via a small-value NP0 capacitor to reduce the tuning frequency range. This can be done using math or by just plain experimentation. C2 is a small ceramic air-variable trimmer from my junk box used to set the lower band edge of the VFO. It can be omitted if the user wants to go frugal and experimentally set the lowest frequency of the VFO using small-value ceramic NP0 caps. Air variable caps for C1 and C2 are mandatory for minimal drift VFO operation. C3 actually refers to 4 NP0 ceramic caps which were used to place the VFO on the correct frequency. Four caps were used to minimize heating and thus drift in the VFO. For the prototype VFO which tunes something ~ 3.00 to 3.67 MHz , I used the mentioned air-variable, four NP0 ceramic caps (20pF, 100pF, 5pF, 100pF) and C2 the trimmer cap that went from 2 - 50 pF.

These values should be used only as a guide for prospective builders as there are many variables at play. Following a 10 minute warm up period, the VF0 frequency stability is excellent. Again, keeps all component leads as short as possible. T1 is a broadband transformer wound by using 20 turns of # 26 AWG over a FT37-43 toroid core and then distributing 5 secondary turns spaced evenly over the primary windings. Do not omit the 33 ohm load resistor. The 2.7 to 3.0 pF coupling cap should also be of the NP0 ceramic type. Q1 can

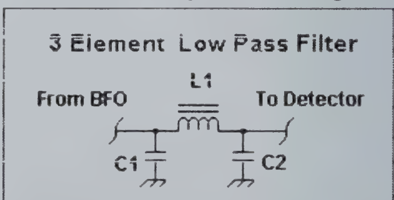
be the J310 (my favorite) , 2N4416 , MPF102 or other correct substitutes. This VFO should be in a seperate sealed, shielded box from the rest of the receiver.



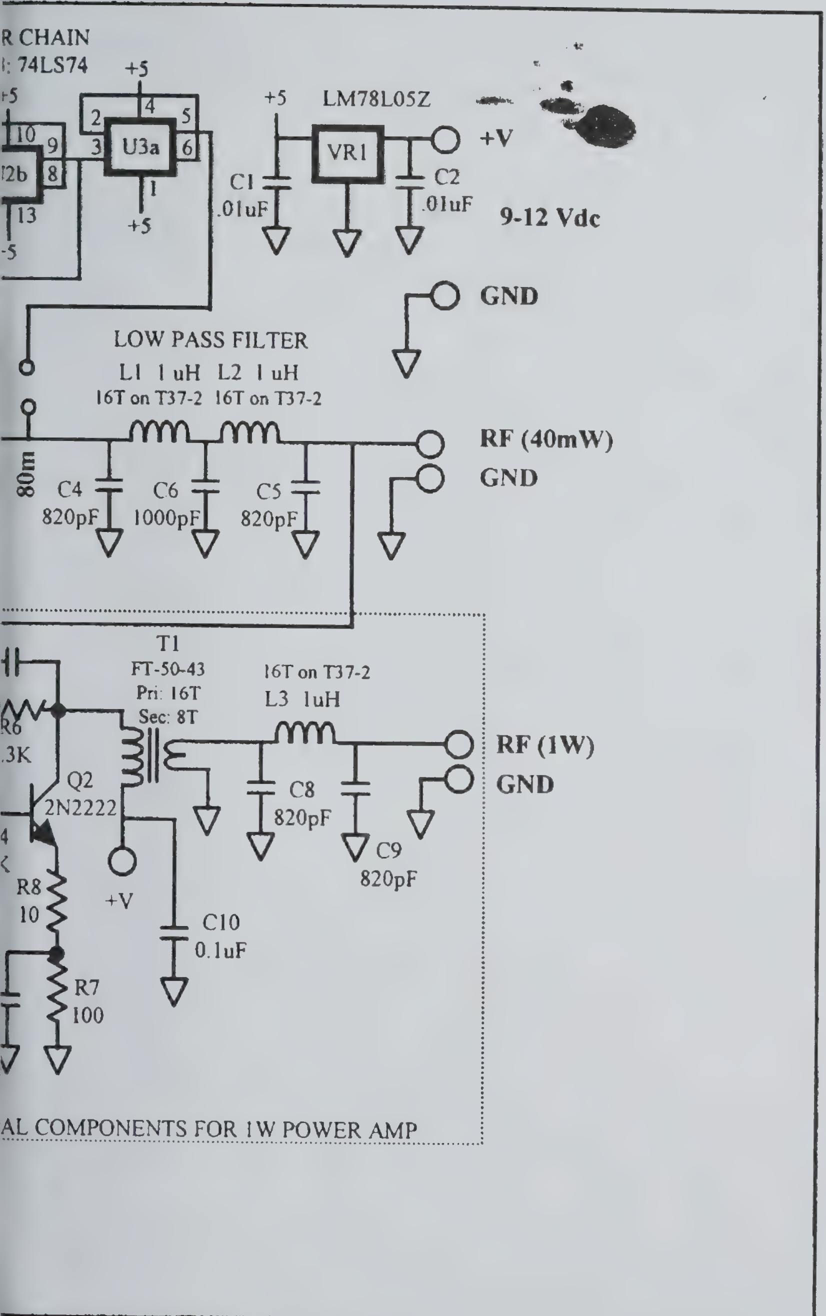
Shown is a 2 stage BFO for use with the ugly 40 meter superhets with a 4.00 MHz IF. This is a design by W7ZOI which I have used from 3.5 to 9 MHz by only changing the crystal and the Q2 output coil and capacitor values to suit the frequency of choice. The output coil is 59 primary and 12 secondary windings on a T68-2 toroid core. You will need in the order of 79 pF to resonate this coil, thus a 68 pF plus a 5-20 pF variable works well.

If you do not have a T68-2 core, a T50-2 could be used with 30 AWG wire which is a bit difficult so you could opt for an XL of 200 ohms which would be 40 primary and 8 secondary turns on a T50-2 core. You would need ~200 pF to resonate such a coil and the BFO would have reduced output power, but would still work okay. If you design your own tank, you probably should not use an XL/XC less than 190 ohms for the output stage at 4 MHz. Use a 5:1 turns ratio for primary to secondary windings.

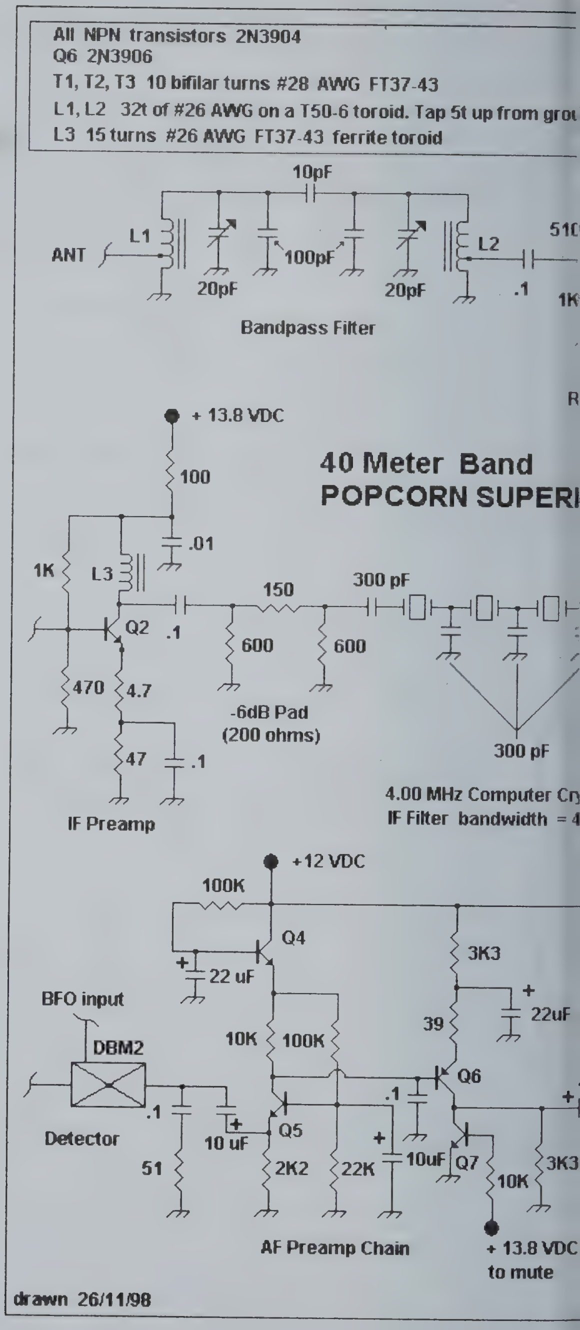
It wouldn't hurt to follow the Popcorn Superhet BFO with a low pass filter. A simple pi-type 3 element filter is suitable. Since I had a couple of 470 pF caps left over, I made a low pass filter using a 6.8

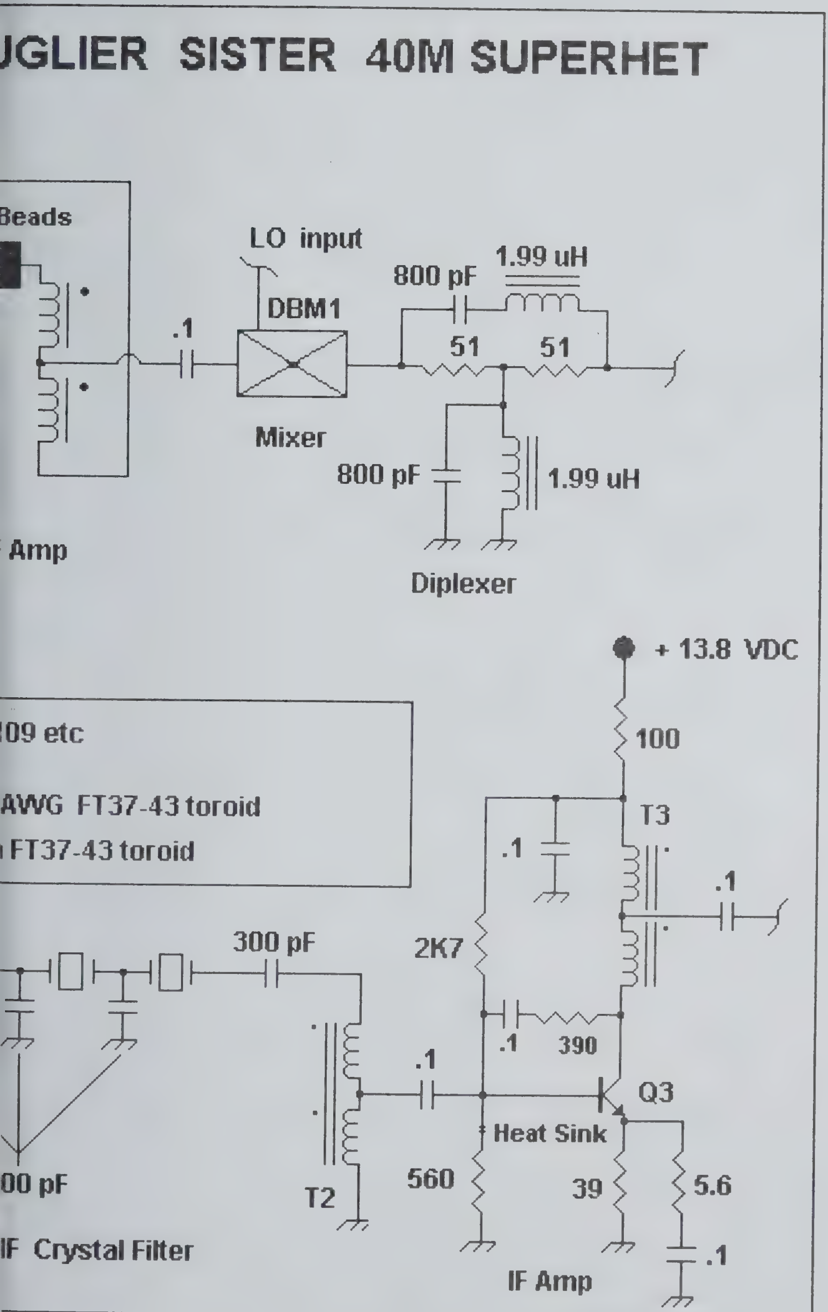


MHz cutoff frequency with a 1.17 uH inductor. A 1.17 uH inductor using a T37-2 core requires 17 turns while on a T50-2 core requires 15 turns. Caps were inexpensive monolithic ceramics from DigiKey.

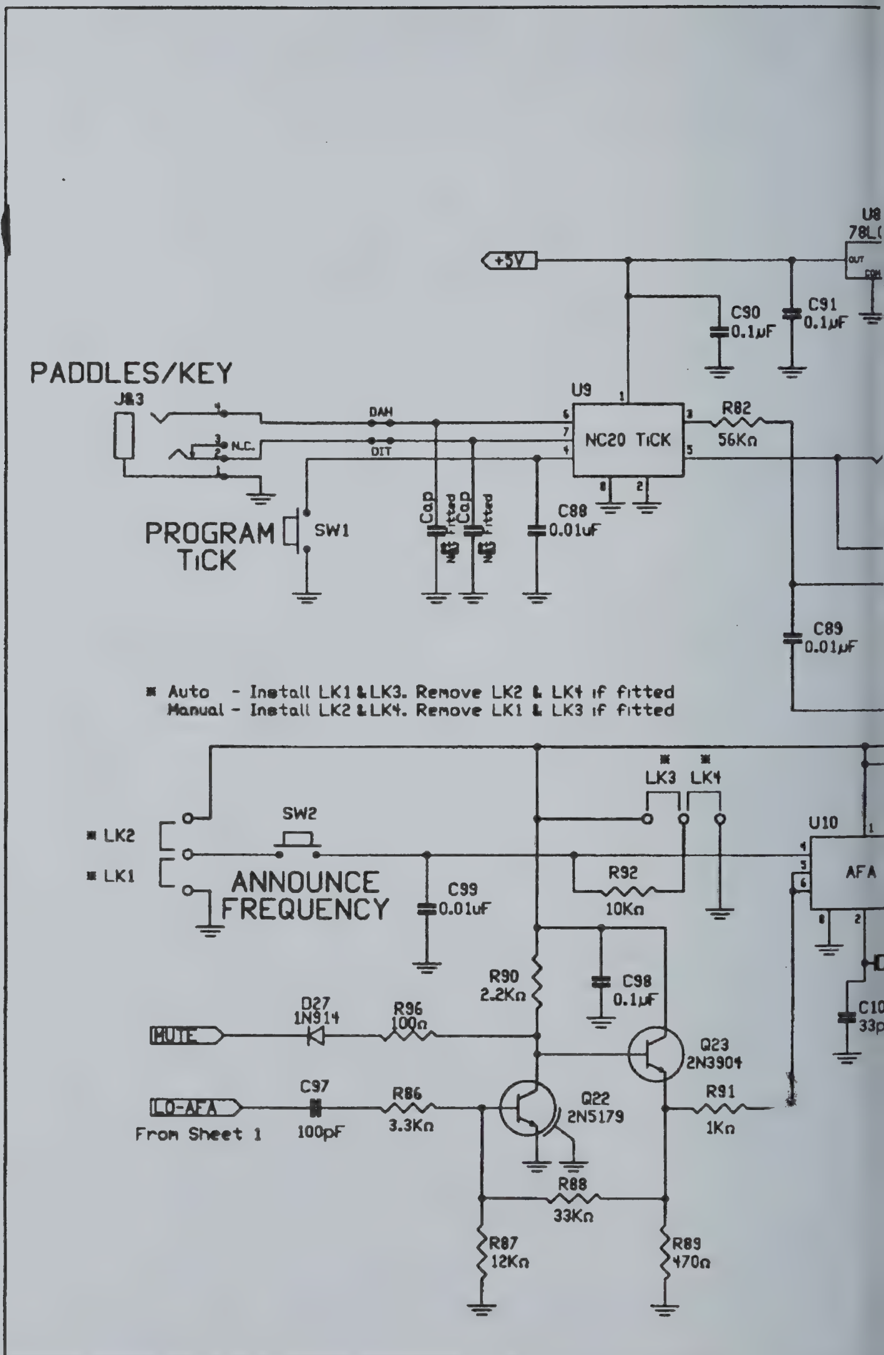


RSEY FIREBALL 40

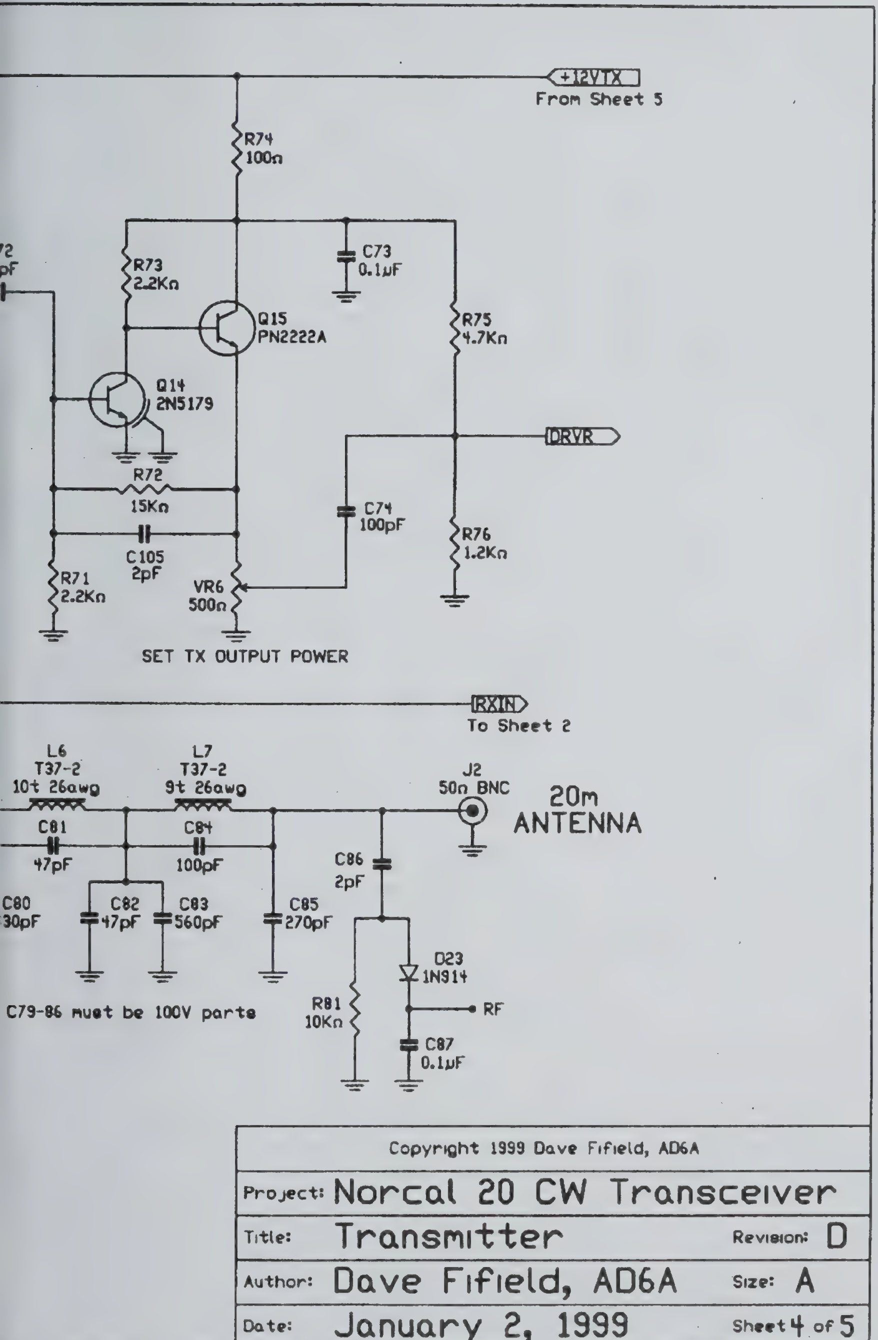

All NPN transistors 2N3904
Q6 2N3906
T1, T2, T3 10 bifilar turns #28 AWG FT37-43
L1, L2 32t of #26 AWG on a T50-6 toroid. Tap 5t up from grou
L3 15 turns #26 AWG FT37-43 ferrite toroid
10pF
ANT
L1
20pF
100pF
20pF
L2
.1
Bandpass Filter
+ 13.8 VDC
100
40 Meter Band
POPCORN SUPER
.01
1K
L3
300 pF
150
Q2
.1
600
600
470
4.7
-6dB Pad
(200 ohms)
300 pF
47
.1
4.00 MHz Computer Cr
IF Filter bandwidth = 4
IF Preamp
+12 VDC
100K
Q4
3K3
22 uF
BFO input
+
22uF
DBM2
10K
100K
39
Q6
.1
Q5
.1
10 uF
Detector
51
2K2
22K
10uF
Q7
10K
3K3
AF Preamp Chain
+ 13.8 VDC
to mute
drawn 26/11/98

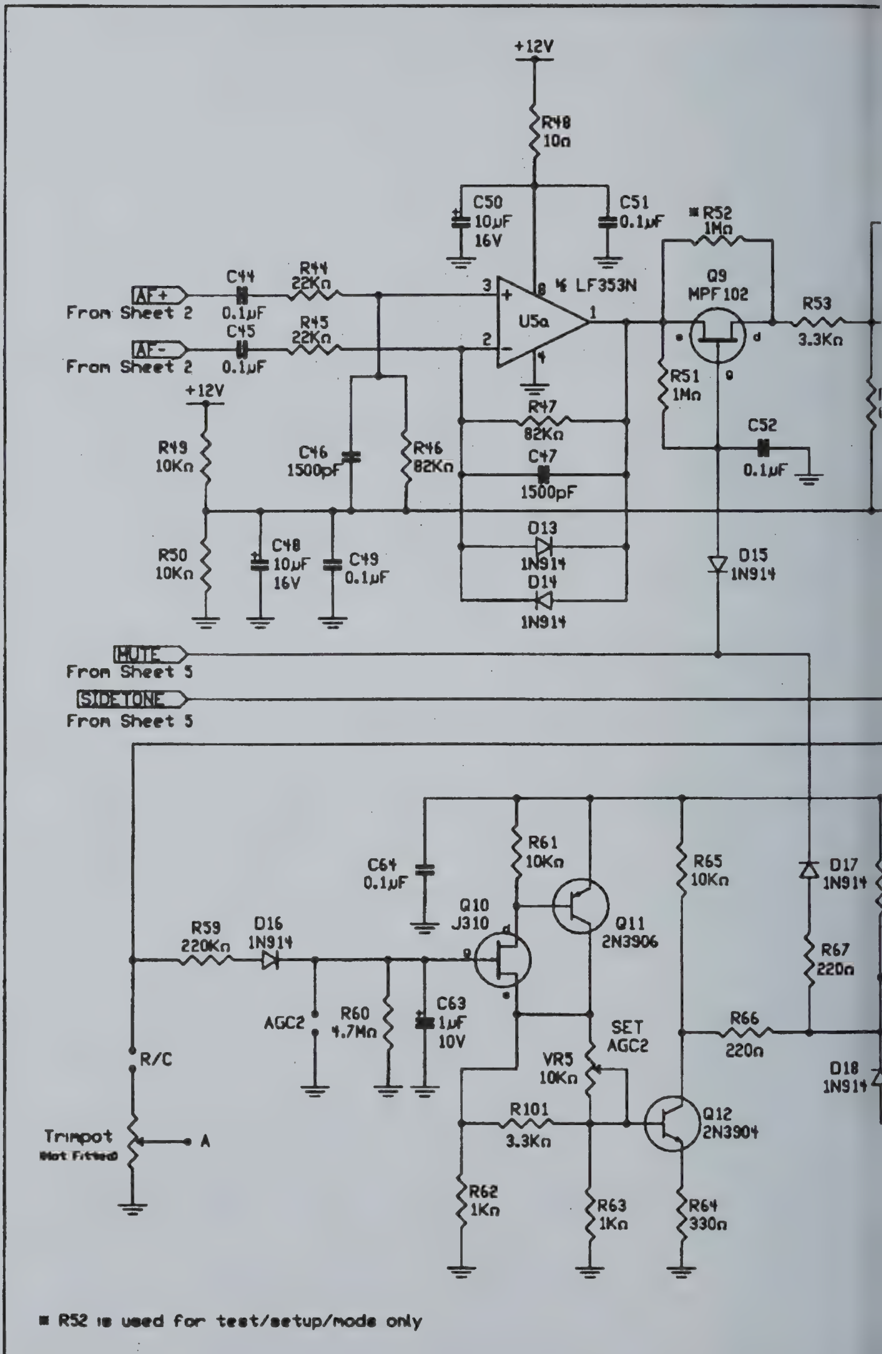


JGLIER SISTER 40M SUPERHET
Beads
LO input
DBM1
.1
800 pF
1.99 uH
51
51
Mixer
800 pF
1.99 uH
Amp
Diplexer
+ 13.8 VDC
100
09 etc
AWG FT37-43 toroid
FT37-43 toroid
T3
.1
.1
300 pF
2K7
.1
390
.1
Q3
Heat Sink
00 pF
560
39
5.6
T2
.1
IF Crystal Filter
IF Amp

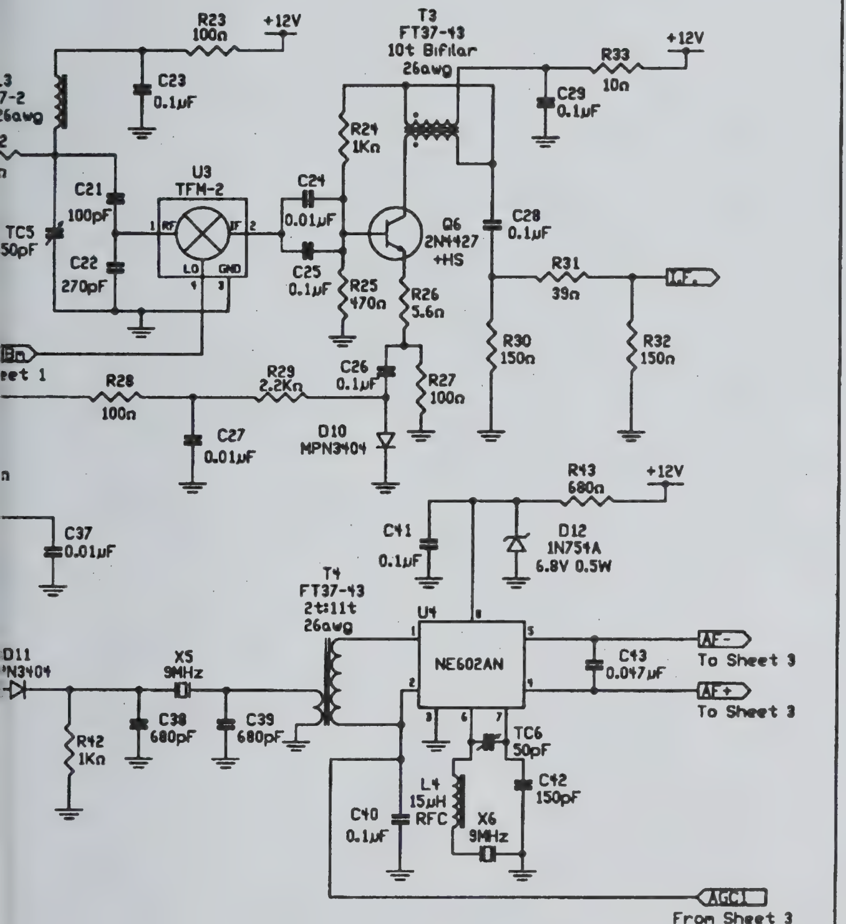


PADDLES/KEY
J13
N.C.
DAH
DIT
U9
NC20 TiCK
R82
56Kn
+5V
C90
0.1µF
C91
0.1µF
U8
78L
C88
0.01uF
PROGRAM TiCK
SW1
Cap Not fitted
Cap Not fitted
C89
0.01µF
* Auto - Install LK1 & LK3. Remove LK2 & LK4 if fitted
Manual - Install LK2 & LK4. Remove LK1 & LK3 if fitted
* LK2
* LK1
SW2
ANNOUNCE FREQUENCY
C99
0.01uF
LK3
LK4
R92
10Kn
U10
AFA
R90
2.2Kn
C98
0.1µF
D27
1N914
R96
100n
MUTE
Q23
2N3904
C97
100pF
R86
3.3Kn
LO-AFA
From Sheet 1
Q22
2N5179
R91
1Kn
R88
33Kn
R87
12Kn
R89
470n


+12VTX
From Sheet 5
R74
100Ω
R73
2.2KΩ
C73
0.1µF
Q15
PN2222A
R75
4.7KΩ
Q14
2N5179
DRVR
R72
15KΩ
C74
100pF
C105
2pF
R76
1.2KΩ
R71
2.2KΩ
VR6
500Ω
SET TX OUTPUT POWER
RXIN
To Sheet 2
L6
T37-2
10t 26awg
L7
T37-2
9t 26awg
J2
50Ω BNC
20m
ANTENNA
C81
47pF
C84
100pF
C86
2pF
C80
30pF
C82
47pF
C83
560pF
C85
270pF
D23
1N914
RF
R81
10KΩ
C87
0.1µF
C79-86 must be 100V parts
Copyright 1999 Dave Fifield, AD6A
Project: Norcal 20 CW Transceiver
Title: Transmitter
Revision: D
Author: Dave Fifield, AD6A
Size: A
Date: January 2, 1999
Sheet 4 of 5



+12V
R48
10Ω
C50
10µF
16V
C51
0.1µF
* R52
1MΩ
AF+
From Sheet 2
C44
0.1µF
R44
22KΩ
AF-
From Sheet 2
C45
0.1µF
R45
22KΩ
½ LF353N
U5a
Q9
MPF102
R53
3.3KΩ
R51
1MΩ
C52
0.1µF
+12V
R49
10KΩ
C46
1500pF
R46
82KΩ
R47
82KΩ
C47
1500pF
R50
10KΩ
C48
10µF
16V
C49
0.1µF
D13
1N914
D14
1N914
D15
1N914
MUTE
From Sheet 5
SIDETONE
From Sheet 5
C64
0.1µF
R61
10KΩ
Q10
J310
Q11
2N3906
R65
10KΩ
D17
1N914
R59
220KΩ
D16
1N914
R67
220Ω
AGC2
R60
4.7MΩ
C63
1µF
10V
SET
AGC2
VR5
10KΩ
R66
220Ω
D18
1N914
R/C
R101
3.3KΩ
Q12
2N3904
Trimpot
(Not Fitted)
A
R62
1KΩ
R63
1KΩ
R64
330Ω
* R52 is used for test/setup/mode only



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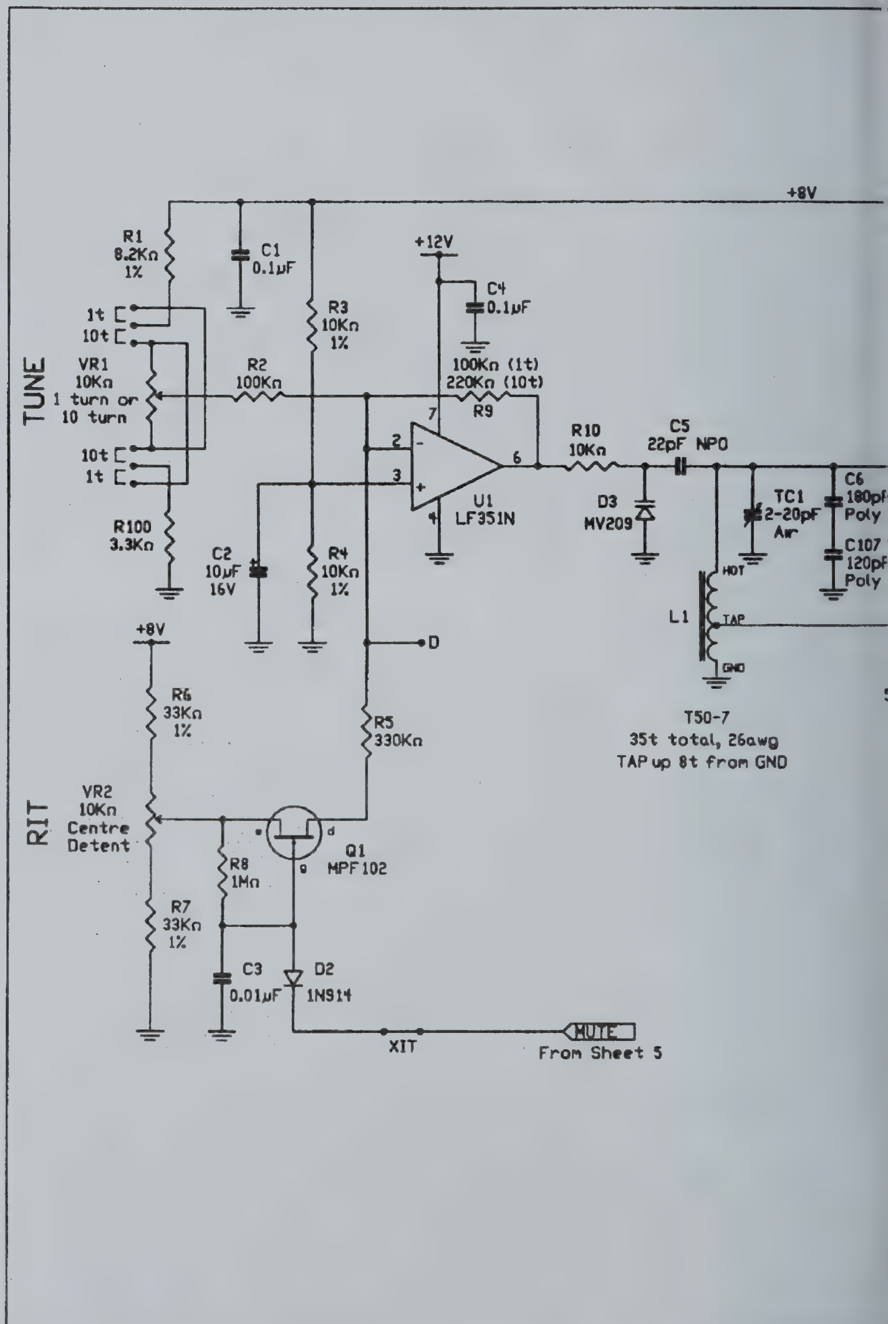
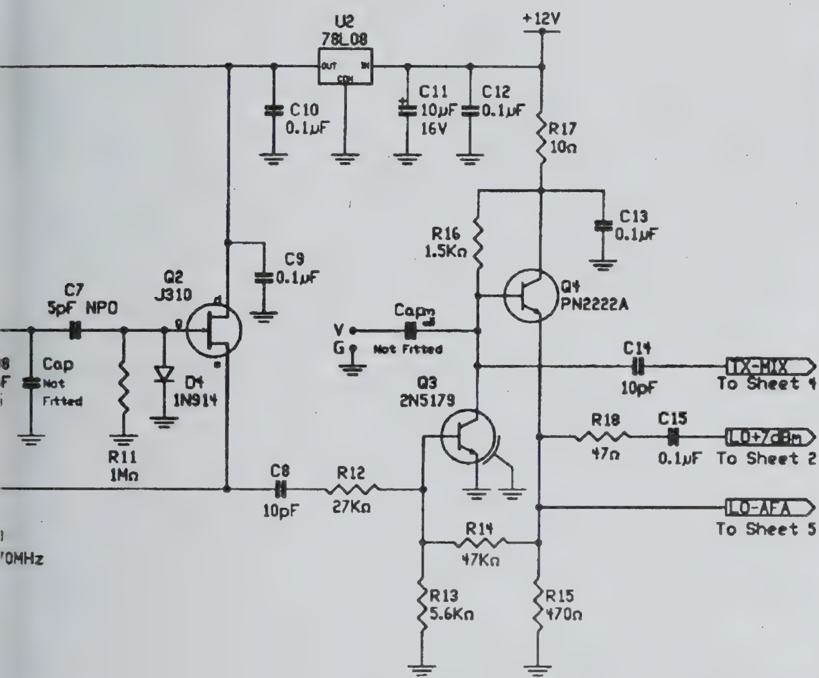
Title:	Receiver - RF	Revision:	D
Author:	Dave Fifield, AD6A	Size:	A
Date:	January 2, 1999	Sheet	2 of 5



+8V
R1
8.2KΩ
1%
C1
0.1μF
+12V
C4
0.1μF
1t
10t
R3
10KΩ
1%
TUNE
VR1
10KΩ
1 turn or
10 turn
R2
100KΩ
100KΩ (1t)
220KΩ (10t)
R9
R10
10KΩ
C5
22pF NPO
U1
LF351N
D3
MV209
TC1
2-20pF
Air
C6
180pF
Poly
C107
120pF
Poly
R100
3.3KΩ
C2
10μF
16V
R4
10KΩ
1%
HOT
L1
TAP
GND
D
+8V
R6
33KΩ
1%
R5
330KΩ
T50-7
35t total, 26awg
TAP up 8t from GND
RIT
VR2
10KΩ
Centre
Detent
Q1
MPF102
R8
1MΩ
R7
33KΩ
1%
C3
0.01μF
D2
1N914
XIT
MUTE
From Sheet 5



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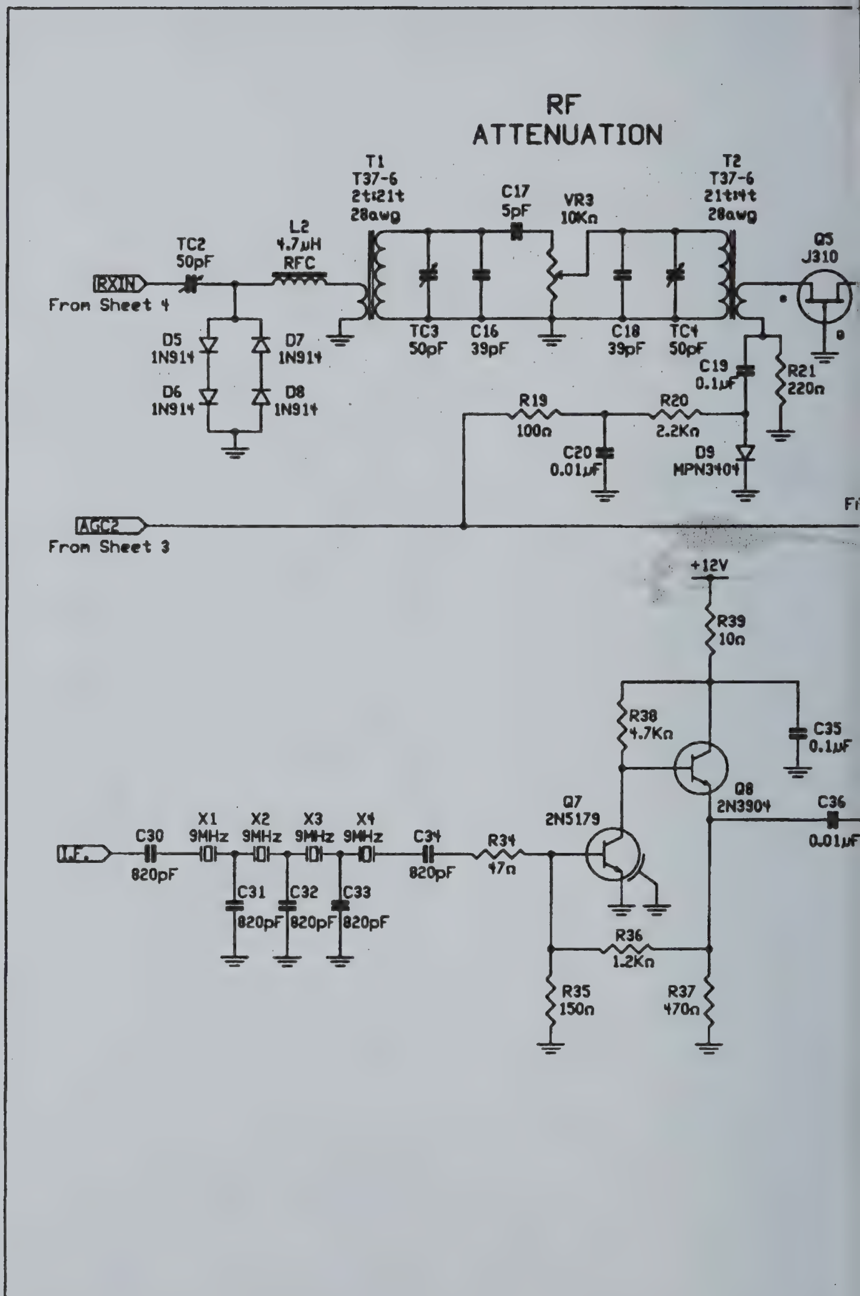
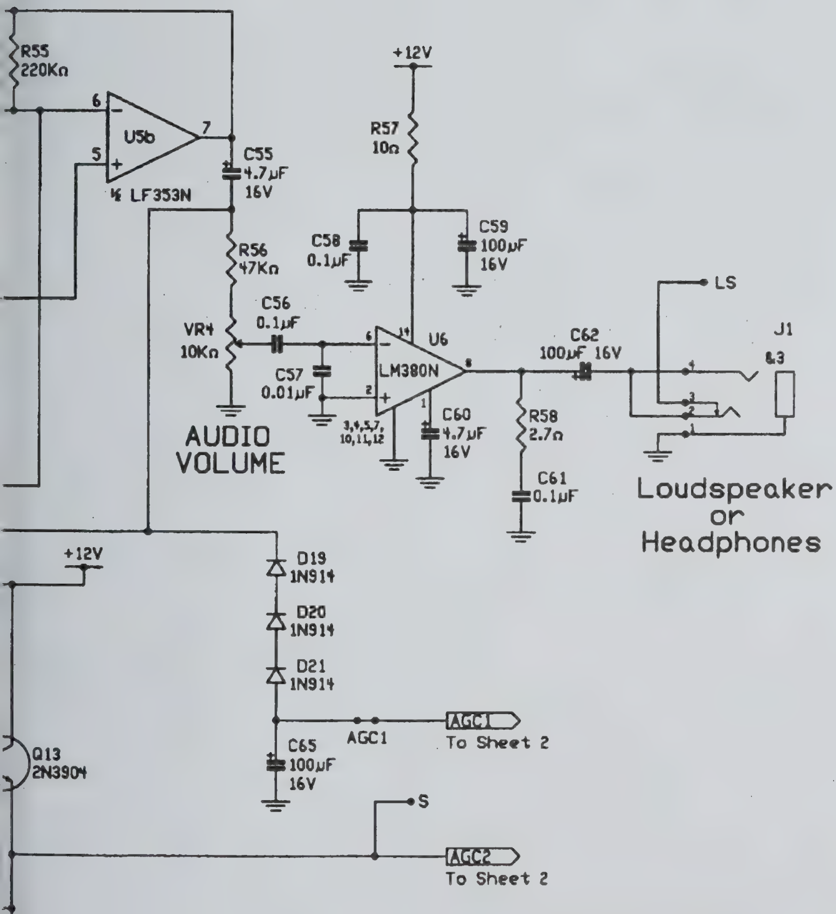
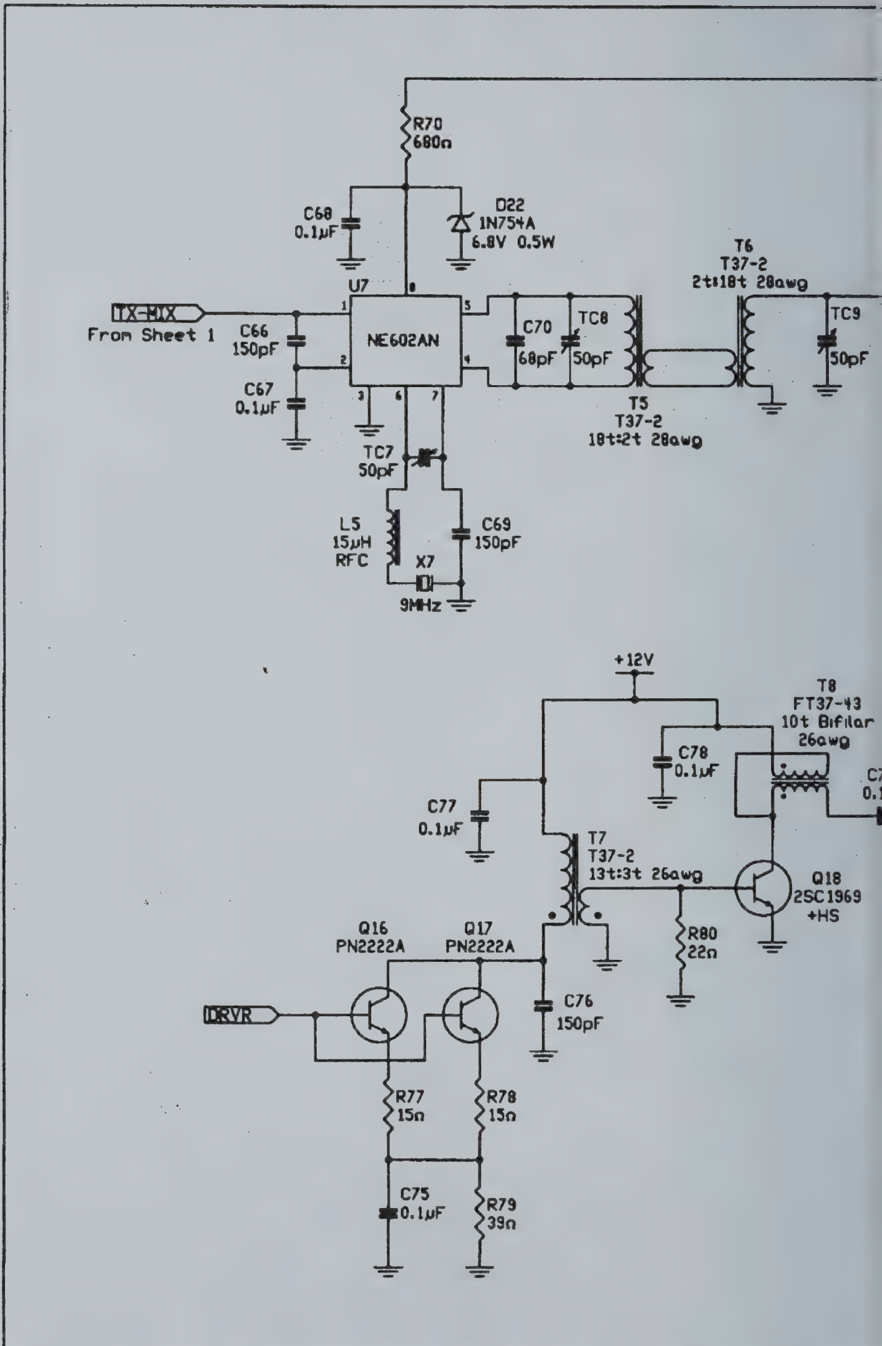
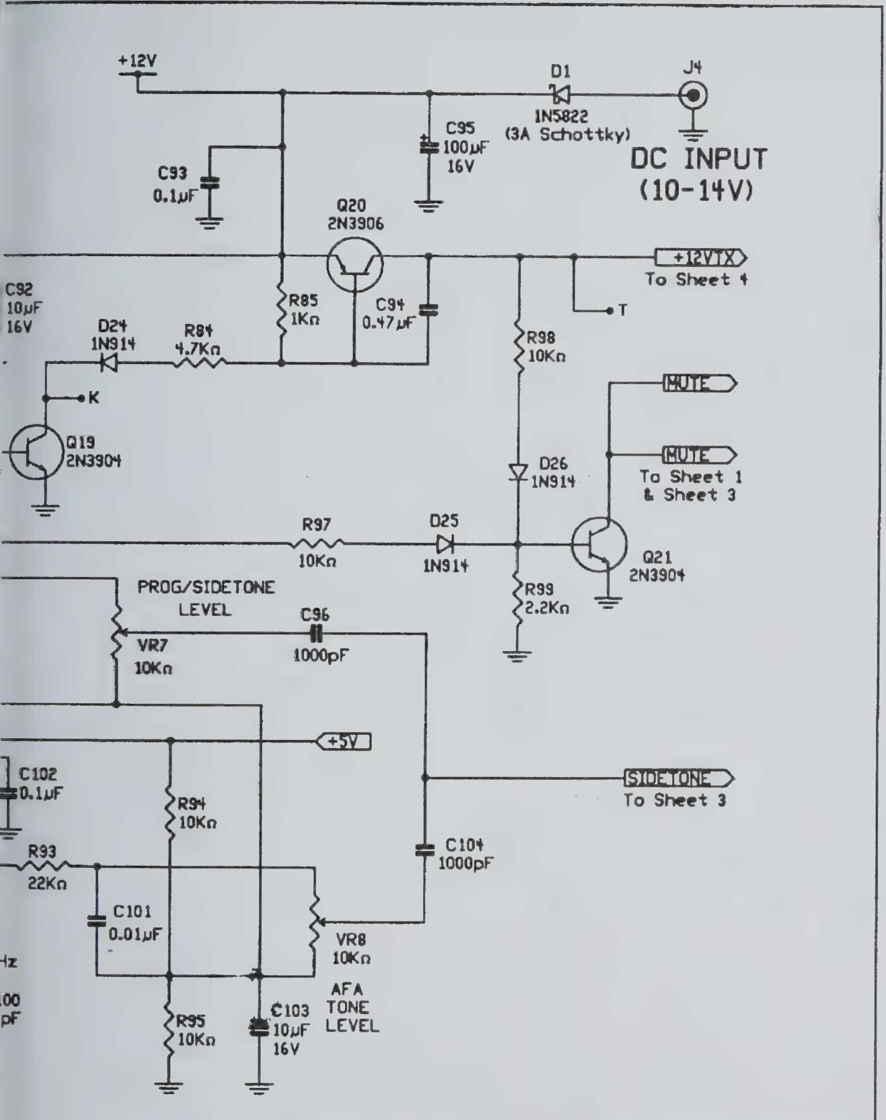
Title:	VFO	Revision:	D
Author:	Dave Fifield, AD6A	Size:	A
Date:	January 2, 1999	Sheet	1 of 5


RF
ATTENUATION
T1
T37-6
2t:21t
28awg
T2
T37-6
21t:4t
28awg
C17
5pF
VR3
10Kn
L2
4.7µH
RFC
TC2
50pF
RXIN
From Sheet 4
Q5
J310
D5
1N914
D6
1N914
D7
1N914
D8
1N914
TC3
50pF
C16
39pF
C18
39pF
TC4
50pF
C19
0.1µF
R21
220n
R19
100n
R20
2.2Kn
C20
0.01µF
D9
MPN3404
AGC2
From Sheet 3
+12V
R39
10n
R38
4.7Kn
C35
0.1µF
Q8
2N3904
C36
0.01µF
Q7
2N5179
I.F.
C30
820pF
X1
9MHz
X2
9MHz
X3
9MHz
X4
9MHz
C34
820pF
R34
47n
C31
820pF
C32
820pF
C33
820pF
R36
1.2Kn
R35
150n
R37
470n

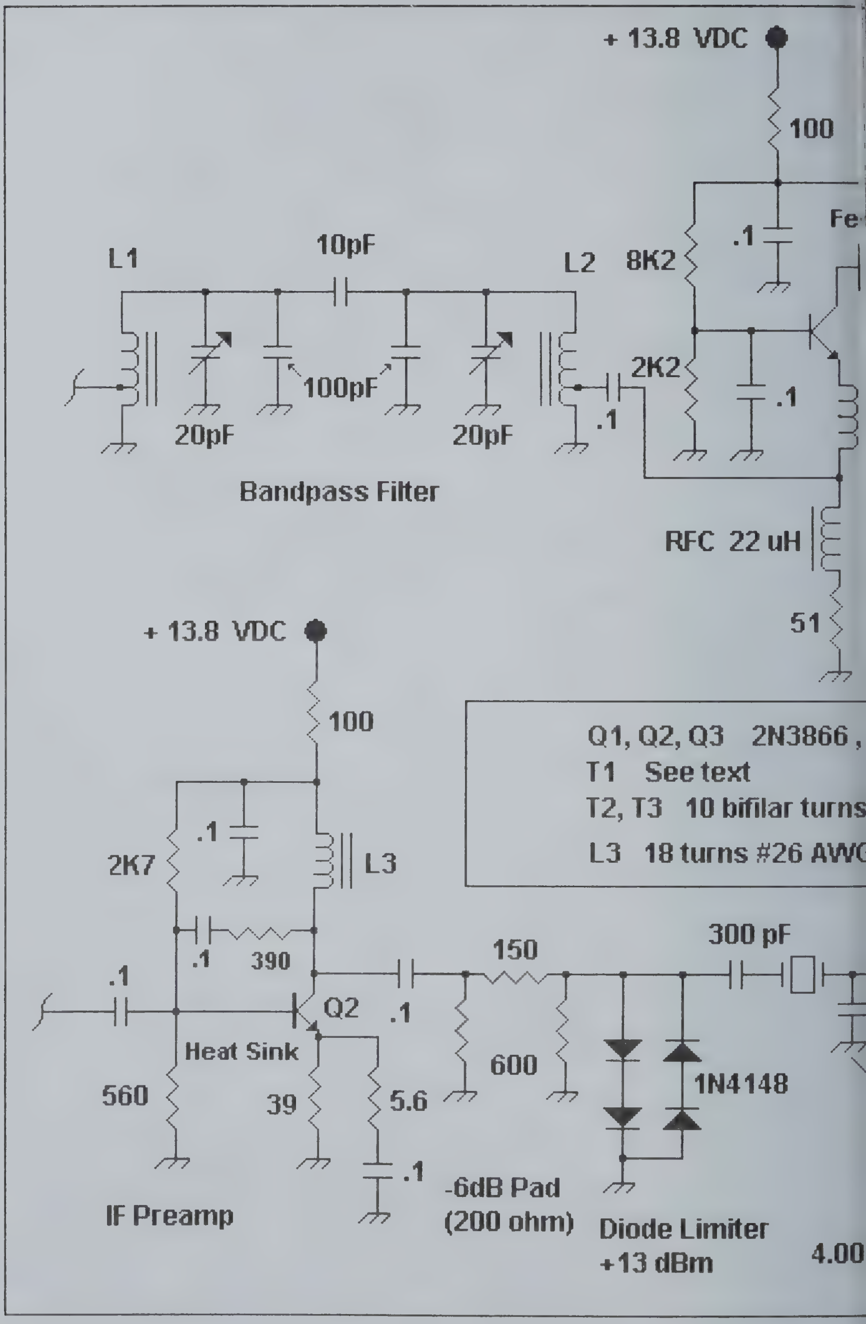


Project:	Norcal 20 CW Transceiver		
Title:	Receiver - Audio	Revision:	D
Author:	Dave Fifield, AD6A	Size:	A
Date:	January 2, 1999	Sheet 3 of 5	


R70
680Ω
C68
0.1µF
D22
1N754A
6.8V 0.5W
T6
T37-2
2t:18t 28awg
U7
TX-MIX
From Sheet 1
C66
150pF
NE602AN
C70
68pF
TC8
50pF
TC9
50pF
C67
0.1µF
T5
T37-2
18t:2t 28awg
TC7
50pF
L5
15µH
RFC
C69
150pF
X7
9MHz
+12V
T8
FT37-43
10t Bifilar
26awg
C78
0.1µF
C77
0.1µF
T7
T37-2
13t:3t 26awg
Q18
2SC1969
+HS
Q16
PN2222A
Q17
PN2222A
R80
22Ω
DRVR
C76
150pF
R77
15Ω
R78
15Ω
C75
0.1µF
R79
39Ω



Copyright 1999 Dave Fifield, AD6A			
Project:	Norcal 20 CW Transceiver		
Title:	AFA & Keyer	Revision:	D
Author:	Dave Fifield, AD6A	Size:	A
Date:	January 2, 1999	Sheet 5 of 5	


+ 13.8 VDC
100
Fe
.1
8K2
L1
10pF
L2
2K2
.1
100pF
20pF
20pF
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Bandpass Filter
RFC 22 uH
51
+ 13.8 VDC
100
Q1, Q2, Q3 2N3866 ,
T1 See text
T2, T3 10 bifilar turns
L3 18 turns #26 AWG
2K7
.1
L3
.1
390
300 pF
150
.1
Q2
.1
Heat Sink
600
1N4148
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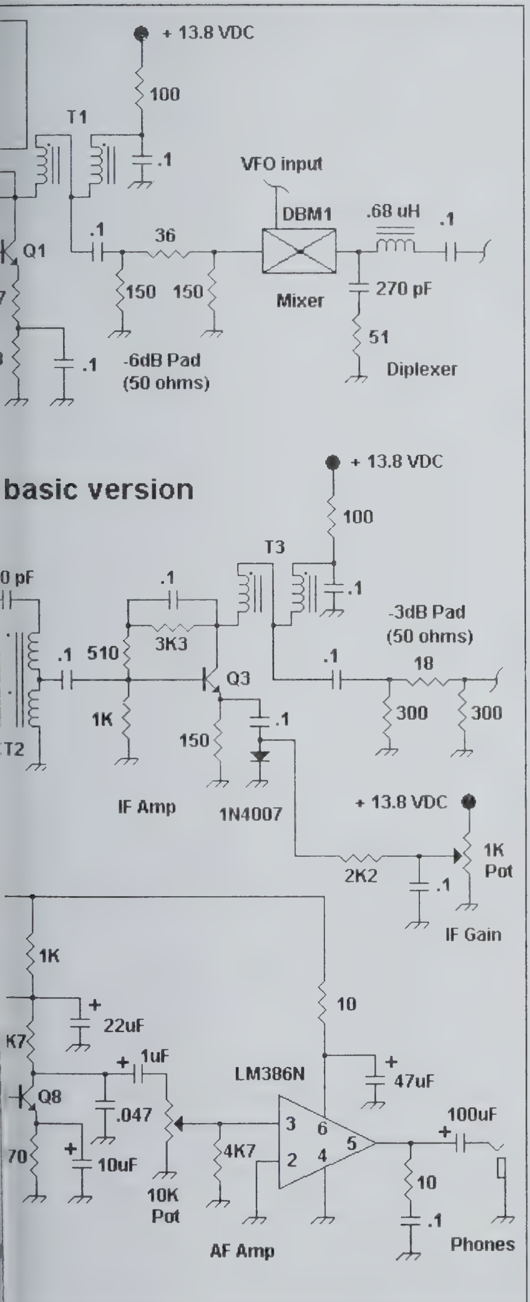
5.6
.1
-6dB Pad
(200 ohm)
IF Preamp
Diode Limiter
+13 dBm
4.00


+ 13.8 VDC
100
T1
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VFO input
DBM1
.68 uH
.1
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36
Q1
150
150
Mixer
270 pF
51
Diplexer
.1
-6dB Pad
(50 ohms)
basic version
+ 13.8 VDC
100
T3
.1
.1
-3dB Pad
(50 ohms)
3K3
.1
510
18
Q3
1K
.1
300
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T2
IF Amp
1N4007
+ 13.8 VDC
1K
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IF Gain
1K
10
22uF
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LM386N
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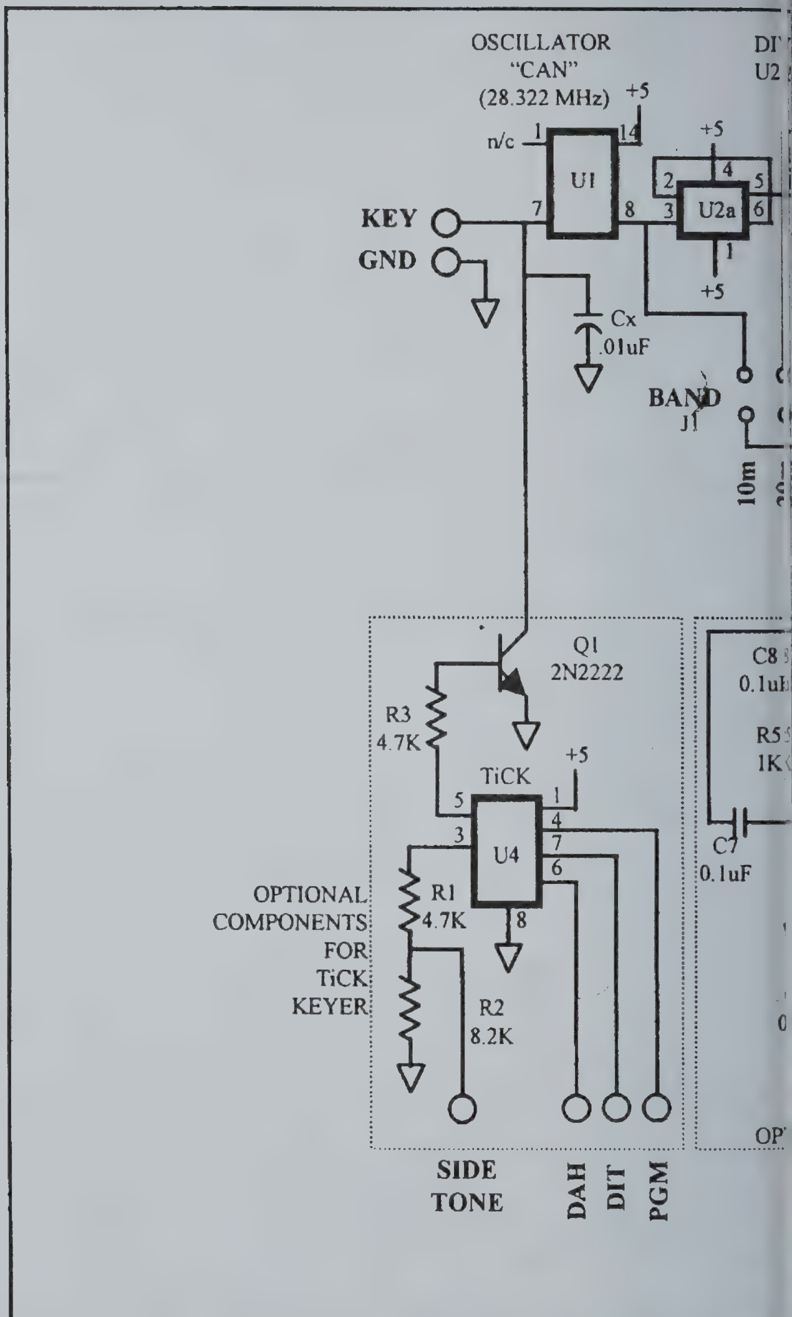
Phones



Schematic for the J

The filter is shown on the previous page, L1 = 1.17uH, C1 and C2 = 470 pF. If you want, you may use other cutoff frequencies to suit any junkbox caps you have on hand and use an XL/XC of 50 ohms.

Construction

Keep component leads as short as possible to promote stability. Do not omit the zener diode D1. I thought of using a small ferrite bead on the base of Q2 and will try it on the next version of this BFO that I make. The BFO, if unstable can break into all sorts of weird AF sound effects that are very annoying. The BFO should ideally be in a shielded box. but many amateurs have good results by just placing the BFO strategically in the receiver chassis. When winding L1, make sure you wind the secondary coil so that the secondary's grounded end is on the cold side of the primary coil that connects to the 100 ohm resistor and positive voltage. I just pick one end of the primary coil and close wind the secondary coil from this point in the same direction for the correct number of windings. Then the starting point of the secondary can be grounded and the other end connected to the detector or a low pass filter. After building the coil, temporarily place a 51 ohm resistor from the secondary output lead to ground. Then you can test and peak the tuning of the output tank into a load. Leave the resistor in place for all your testing work such as crystal matching or RF stage testing until you are ready to connect it to the product detector. The 60 pF variable cap connected between the crystal and ground is used to set the beat frequency of the BFO. Adjust it to get a good sounding beat note when listening to a station. You will notice that the beat frequency can be tuned roughly by just listening to 40 meter band noise in the headphones and then tweaked on an active QSO.

Product Detector and Diplexer

A diode ring mixer is used for a product detector. Following the detector is a simple audio diplexer to help terminate the mixer products with a 50 ohm impedance. The diplexer is similar to the one used in the Ugly Direct Receiver on this website. The 2.7 millihenry inductor is hand wound on a FT37-43 toroid and the method for construction is located on the just-mentioned web page. If you choose not to use the 2.7 mH audio inductor, replace it with an inductor wound with 10 turns of #26 AWG on a FT37-43 ferrite core. Also replace the 1uF capacitor to the right of the 2.7 mH inductor in the schematic with a .01 uF unit. Capacitors in the diplexer must be non or bipolar.

AF Chain

The AF chain of this receiver pretty much follows the one used in the sister receiver except for a little more decoupling. The 22 ohm resistor on the emitter of Q6 can be decreased down as far as 10 ohms or increased to as high as 150 ohms to trim the maximum volume into a speaker or headphones. The lower the resistor value the more gain is realized. Transistor choices for Q5, Q6, and Q8 are numerous. Consult the Ugly Direct project for a list of NPN transistor choices. Q6 is a 2N3906 or 2N5087. Low-noise 2N5089s and a 2N5087 were used in the prototype receiver. Q7 is used for muting the receiver and can be omitted if a mute feature is unwanted. An LM380N is used as the final AF amp. A different audio amp can be used such as the LM386N or the new SSM2211 IC to suit the builder. If you remove the negative feedback from the LM380, place a 0.1 uF cap from pin 6 to ground. Remember to keep your leads short as possible in the AF chain or motor boat and/or train whistle noise may plague your receiver.

The DL-QRP-PA - A Home Made Project

by Peter Zenker, DL2FI
(Translation of an article in QRP-Report, the magazin of the DL-QRP-AG for QRPp)

QRP means 5 Watt carrier output or 10W PEP, at least this is the international definition. While it would seem to be easily done, this is assumed by many Hams to not be a technical issue. But this is not true as you will see very quickly if you have a closer look at the PA of many QRP Rigs.

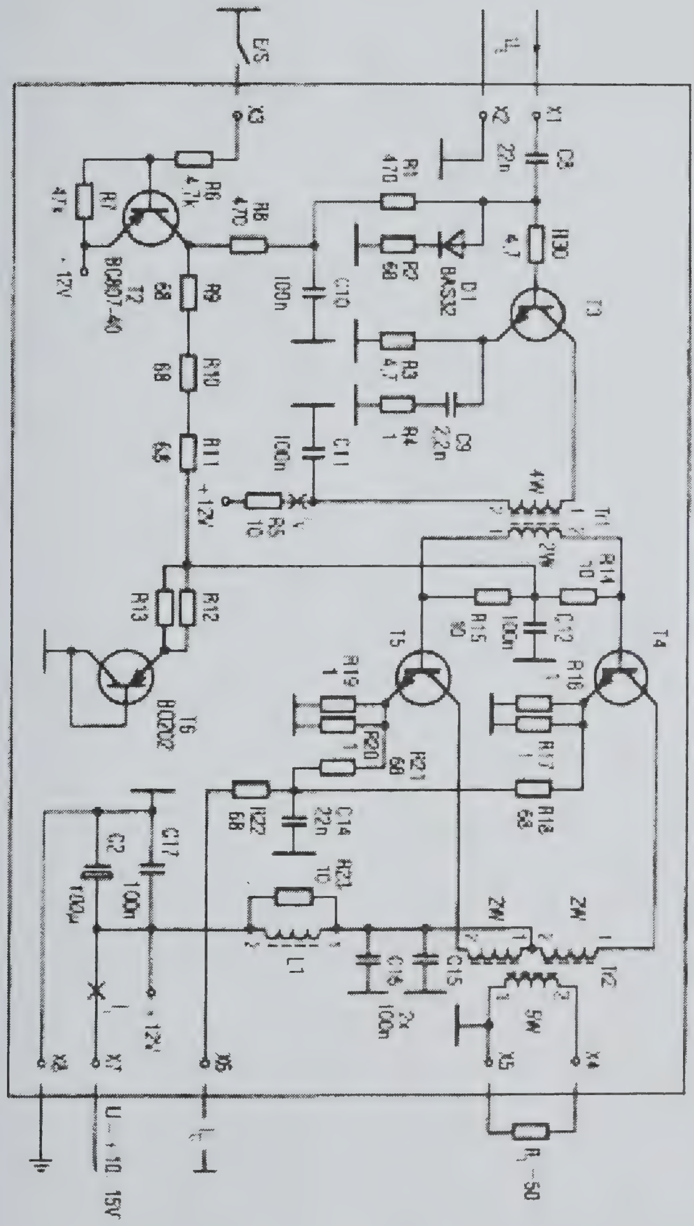
While homemade QRP-receivers are often highly sophisticated, the transmitter part of most QRP-rigs are usually quite simple. As a type of standard normally most constructors use a single step PA. Recently, very often cheap V-MOS switches are used instead of real bipolar RF-Power transistors. To meet FCC rules, the PA normaly is followed by a sumptuous lowpass filter which also very often does not help enough. Hams trying to build their own rigs based on such designs, even if they use kits, almost never reach the assumed power level especially on the higher frequencies. This results in dozen and dozen of tweaking procedures every time a new schematic or a new kit appears.

In the past I have tried several of the tweaking procedures myself. Following the instructions given by lots of people on the Internet QRP-L or in other Ham Radio publications I tried nearly all published modification for the NorCal40, the SIERRA and some 10 to 15 other rigs. Using simple measurement techniques some of the modifications seemed to work great, e.g the power of my SIERRA at 28 MHz was more then doubled. Using a high tech Analyzer which I borrowed from a friend I had to learn that power is not power. What I had seen on the DummyLoad plus wattmeter was shown at the Analyzer as a broadband noise. In other words, My modified SIERRA produced RF at severel frequencies up to the UHF range, but at the desired 28 MHz frequency I found the same output as before.

And old law in RF says: If a PA is well designed, every thing in it does what it is designed to do. If the Output transformer is designed to run at 2 Watt level, tweaking it to 5 Watt normaly results in increasing harmonics without changing the complete design.

The designer of the DL-QRP-PA Helmut, DL2AVH has worked on this problem for many years. Since the early 80's one result of his experiments is the knowledge that miniaturizing of semiconductor power amplifiers is a way to go that helps a lot. The reason for miniaturizing is the fact that even in 5W RF-Amplifiers currents are very high. Compared to a 5 Watt Valve PA he calculated that due to the high current the line length of all lines between any two points of a semiconductor PA have to be 600 times shorter then in a valve PA. This could only be realized by using SMD parts. The second result of his experiments was that he now only works on push-pull amplifier concepts. As he says, push pull amplifiers don't cost much more, but give you much better results in terms of harmonics then any other type of PA. Even with some overloading as is quite normal in Amateur Radio transmitters causes only very little more harmonics in a push pull amplifier but make a standard PA to be a type of big harmonic gun.

Using some of the QRP-PA´s I´ve seen in my lab would give you at least some bad comments by angry friends. While



Schematic of DL-QRP-PA

testing such a PA at 3515 kHz my friend DL7ARY phoned in asking me why I not was responding to his call at 7030 kHz where he could hear me with an S7 signal.

Experiments with severel V-MOS PAs showed that due to the characteristic of V-MOS it is nearly impossible to get linearity and good harmonic suppression below 28 Volts. At 12 Volt range they can only be used as a switch, but not as a PA for RF.

As a result of his long time experimenting Helmut now presents his RF broadband amplifier devoted to the DL-QRP-AG. It is a push pull PA using a pair of 2SC1971, designed to give a harmonic level as small as possible, to work absolutely stable between 11V and 15V and to give an output level of 9.7 Watt to 7.5 Watt between 1.8MHz and 50MHz. The PA needs a driver level of about 200mV to 300 mVand has a gain figure of 37 dB +- 1dB over the entire frequency range of.

It is constructed on a double sided PC-board about 1 by 1 inch, using 36 SMD parts, two double hole torroids plus 3 RF Transistors and one constant current source. As a first batch we produced 100 of this PA. About 50 have been sent out in Kit form and the other 50 have been sent out as a kit to members of the DL-QRP club DL-QRP-AG. The response was overwhelming. Allthough some people had problems with the SMD parts (I personaly used an extra big magnifier), not one reported problems on the RF side. In the meantime the DL-QRP-PA has been adopted to nearly all known QRP-Rigs. It works absolute great in my SIERRA and in the QRP+ from Index as well. The harmonics of the SIERRA are at least -65 dBC (below carrier) I got response from German White Mountain users which are happy now and it also fits great into a NorCal40.

The PA is no longer availeable from the DL-QRP-AG, but it can be purchased as a SEMIKIT from the FUNKAMATEUR Reader Service. (Thats a big German Amateur Radio Magazine) They offer a kit with all SMD parts already soldered :-) for a very reasonable price. You can order the PA using the Internet shop at http://www.funkamateur.de. The shop is partialy english language, prices are in USD and you can use your credit card.

Rochdale QRP Convention 1998

by Tony Fishpool, G4WIF

Following shortly after Pacificon comes the premiere British QRP event - the annual convention at Rochdale in Lancashire. By the time G3MFJ & I had reached the motorway that takes you from the county of Yorkshire to Lancashire, the rain was more like sea with vertical slots in. Thus it was to continue for the whole day.

Not surprisingly, this didn't dampen the enthusiasm of the visitors who flocked to the hall at St. Aidens Church, where George G3RJV carries out his "day job". Within a half hour of opening, the place was packed, and it was with some relief when the lectures started in the adjoining church, and the crowd in the hall thinned out a little. John G0BXO our membership secretary, and Graham G3MFJ our database manager, were kept busy on the club stand enrolling new members and renewing subscriptions. Playing hooky from the Kanga stand, I attended a very entertaining talk by the club treasurer Peter G3PDL, who

spoke about portable operation with a particular emphasis on using telescopic roach poles to hold up various vertical antenna. Other Rochdale regulars David Stockton and Practical Wireless editor Rob Mannion also spoke to a packed church.

Later, back in the hall, there was an auction from the estate of two silent key members. Ian G3ROO and Dick G0BPS took it in turns to squeeze a pound or two from the assembled crowd. Several choice items came under the hammer and Ian got into a bidding war over a Heathkit HW9, saying that he had sold his a good while ago and wanted one again. Ian finally got his wish, and as Dick handed it over he was seized with laughter - the manual had written on the cover "Property of G3ROO". The rig had gone through several owners and Ian had bought it back again - at £5 more than he sold it for!

After the convention had finished, the party mood continued back at the vicarage with about fifty or so people tucking into a huge Chinese "take out". A space was cleared on George's workbench and Steve G0XAR and Jan G0BBL produced a project upon which they had been working with Alan G7PUB.

It's a receiver based on the R2 by KK7B and was married up with not one, but two DDS's and all controlled with a PIC. The acid test was to put it on 40m, which in Europe in the evening, is a good test for any receiver. It received extremely complimentary remarks from many, including Ian G3ROO and Sheldon Hands GW8ELR who said he was "very impressed" with the performance. Obviously, this project is in the early stage right now, but we saw it first at Rochdale.

Another first was a demonstration of the G3MFJ Wobulator. This simple but canny piece of test equipment will make aligning receivers virtually child's play. Hopefully, we can twist Graham's arm to write it up soon for SPRAT.

Later I sat at George's PC, with a bucket full of floppy discs, copying a number of past SPRATs. By the time this report is published, the project will no longer be secret, so keep an eye out on the club website (www.btinternet.com/~g4wif/gqrp.htm)

Bill Hickox K5BDZ almost certainly travelled the furthest to attend the convention. Having come all the way from Texas, he said it was well worth the journey. We greatly enjoyed his company too and the QRP chattering went on until the wee hours. Finally, I discovered why the convention is always on a particular weekend each year. It's the night that the clocks go back an hour and George can at least get some sleep before getting up for work on Sunday morning!

Kitbuilding 101

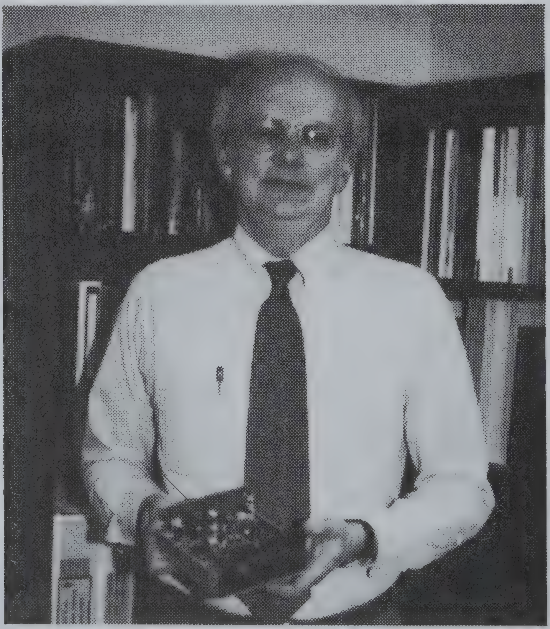
By Dave Sumner, K1ZZ
k1zz@arrl.org

"Dave, if I send you a NorCal 20 kit will you build it?" That's how Doug Hendricks, KI6DS, capped a description of NorCal's goodwill project during a visit to ARRL Headquarters last summer. "Sure!" I replied, not knowing quite what I was getting into but emboldened by his promise that the kit wouldn't be ready for a few months yet.

In February, a videotape-sized package from Doug showed up at home. Sure enough, it was the NC20 kit. If I'd thought Doug would forget his generous offer and let me slip off the hook, I was out of luck. A few weeks later I'd run out of excuses to postpone the project; after all, at that time of year in New England there's not a lot of yard work to do unless you're into mud sculpture. True to kitbuilders' tradition, I commandeered some space on the dining room table and opened the box.

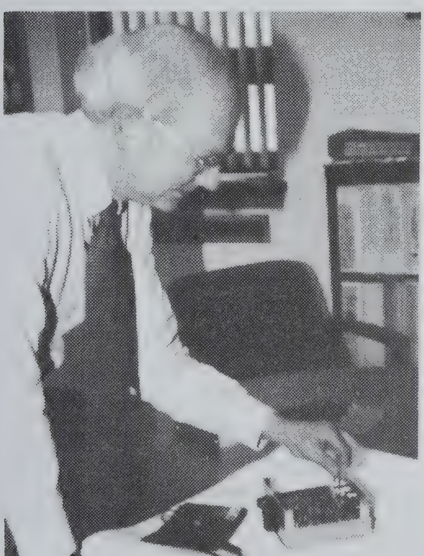
Lest anyone think I've been a pencil pusher all my life, I cut my teeth in electronics at age 14 by working afternoons and weekends in a radio/TV repair shop. My boss was a ham, W1GEA, who had spent his whole life in a wheelchair with cerebral palsy. Self-educated in electronics, he used kids like me as his hands. When the repair business was slow he'd have me build one-tube converters for local reporters so they could listen to police calls on their car radios, or put together an AM transmitter for him from a schematic he had in his head, or maybe replace the capacitors in his Hallicrafters TV set (yes, I said TV set) just for the exercise.

But that was 35 years ago. For the past couple of decades my main interest in home construction has been antennas, and



Dave Sumner, K1ZZ proudly displays his NorCal 20 Transceiver

my soldering mostly confined to coax connectors. Still, I figured, how much different could the NC20 be from the wiring of octal sockets that I remembered so fondly from my youth? Then I started pulling the tiny components out of the box. With the benefit of hindsight it is now obvious that I should have invested immediately in a magnifier, and perhaps in a better soldering iron than the one Santa had procured at Radio Shack for my Christmas stocking a couple of years ago. At the time it seemed a point of pride that I should be able to identify the components without artificial assistance, and to solder them in place with the sort of equipment that might be available in a developing country — after all, that was the real purpose of the project. wasn't it? Fortunately, luck was with me and as we shall see, neither of these self-imposed constraints seriously interfered with eventual success — testimony more to the competence of the designer than to my skill as a constructor.



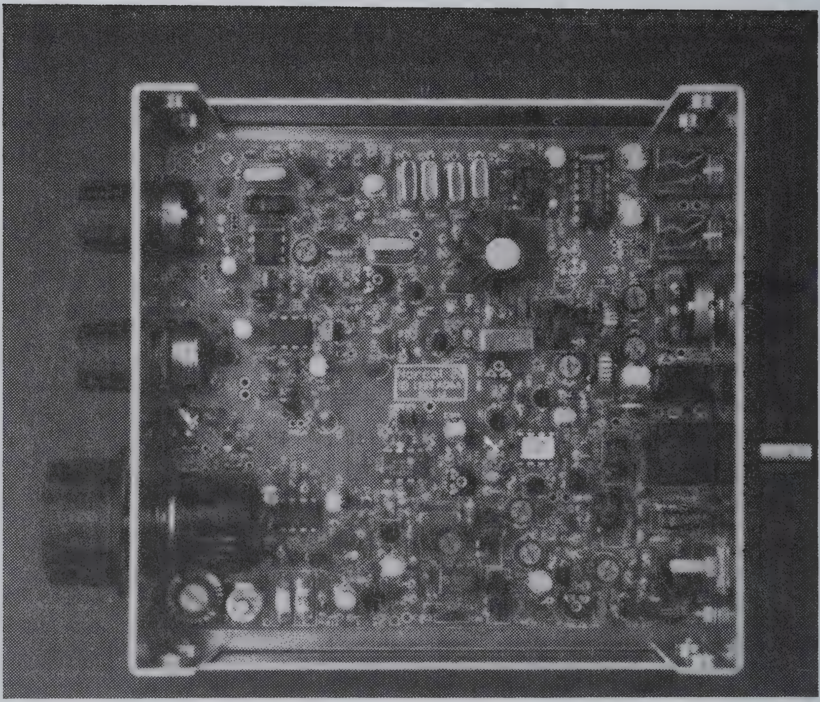
Dave gives his NC20 a final tweaking at the ARRL offices.

In my haste to begin populating the circuit board I skipped checking the parts actually supplied against the parts list. This wasn't a fatal mistake, but it did later cause me to think the 6.2K-ohm resistor was missing when in fact it was just a different color. In a couple of hours the first night I finished the first four of 16 sections in the construction manual, checked the voltages, and went to bed feeling quite smug. This was going to be a piece of cake. Obviously, the hard part had been simply getting started.

Well, maybe not. On my first attempt to wind L1 I used up too much wire in making the tap and had too little left over for 35 turns. When I got to Section 7 I couldn't find an instruction to install R1 and R100, but from the schematic it was obvious they had to be there for the circuit to work so I put them in anyway. (Later Doug told me this omission had been reported on the NorCal reflector, but I didn't discover this incredibly useful resource until after I was done.) Everything else through Section 9 went just fine.

Then I hit my first major obstacle: the Audible Frequency Annunciator wouldn't. Annunciate, that is. No matter how many times or how hard I pushed the button, nothing happened. I listened for the VFO in my FT1000MP; it was oscillating just fine, and I trimmed it onto frequency using the 'MP for calibration. I could also hear, weakly, the 100-kHz oscillator associated with the AFA. E-mail consultations with Doug and designer Dave Fifield, AD6A, revealed that the problem most likely was a rogue AFA chip, which Doug promised to replace immediately. In the meantime I decided I could do without the AFA for the moment, so I pressed on toward the finish line.

At Section 12, playing with the TiCK keyer was so much fun that it almost dis-



This photo shows the excellent job that K1ZZ did building his NC20

tracted me from completing construction. What an ingenious little device! Still, I was anxious to hear real signals so it was time to move on. Soldering wires to the crystal cases was a challenge. The instructions say, "you should be able to tin it fast enough that you can hold the crystal's metal case with one hand while you do the tinning, and not get burned." Right. If that's on the final exam for Kitbuilding 101, I flunk. Either all that sun you California guys are exposed to has toughened your skin, or metal doesn't conduct heat as well out there as it does here. Fortunately, the crystals were more forgiving than my fingers. You may have heard of the Stockholm Syndrome, in which hostages begin to sympathize with their captors. Something similar may happen to kitbuilders: by the time I had finished the receiver I was actually beginning to enjoy winding toroids.

Now, building a kit isn't quite the same as assembling your own creation from scratch — particularly when you're blessed with a board of the high quality that's used in the NC20. The real credit belongs to the designer, not to the builder. Even so, I confess to feeling quite a rush when I hooked up the power and the antenna and immediately heard signals. On to the transmitter!

In Section 15 I found I was one trimmer capacitor short, and spent all the time I'd saved by not checking the parts list on

locating a suitable replacement in my junk box. Well, how suitable it was would be a matter of opinion. It was the right value, 8-50 pF, but about 30 years old and so oversized that it looked as out of place as a 1953 Buick at a Ferrari dealership. Still, I couldn't wait to get on the air and figured it ought to work — 20 meters isn't exactly UHF — so I put it in and headed for the home stretch.

Plugging in the last toroid, I hooked up the antenna, headphones, keyer paddle, and power and prepared to conquer the world. Unfortunately, it quickly became obvious that the rig was more QRP than intended: there was no measurable output and the signal was weak in the 'MP receiver. Something was wrong. I unhooked the power, keyer paddle, headphones, and antenna and carefully examined the underside of the circuit board. Sure enough, there were not one but two solder bridges in the transmitter section. I heated up the iron, fixed those, hooked everything back up again, and my 10 hours of mostly enjoyable labor was finally rewarded.

Alignment was easy. I set the output at a smidge below 5 watts. Now, would anybody be able to hear this cute little toy? Tuning from the bottom of the band, the first CQ I heard was from ZA1D. Should I give him a call? Why not? Sure enough, he came back — as did RZ6ALP, LZ1OJ, UA9MHN, UN7BQ, UA9UY, 4K9W, UA9JMM, I6DVC, UN7CS, UA4PNL, and RV6HA that first night.
Compared to working the same sort of DX with the FT1000MP, which is a fine piece of equipment, I'd have to say the joy is inversely proportional to the price of the radio.

In the interests of full disclosure I'm compelled to reveal that my antennas are inconsistent with the QRP life style. On 20 I have stacked 4-element yagis at 104 and 52 feet. (The lower antenna is fixed on Europe, not that I expect any sympathy for this handicap.) Even when tickled with just 5 watts, the stack offers an edge over the guy running 100 watts to a trap vertical. I know I should string a dipole at 30 feet to fully savor the QRP experience. On the other hand, from previous QRP forays (I'm an honorary member of the G-QRP Club and a sometime participant in QRP events) I know that having a good antenna at my end gives someone with a simple antenna a chance for a QSO that might not otherwise be possible.

A couple of days later, another package arrived from Doug with a replacement AFA and trimmer capacitor and, unexpectedly, a 10-turn pot. Thanks, Doug! Desoldering was more difficult than soldering, but before long I was back in business with a fully functional AFA (another ingenious device) and coverage of the bottom 84 kHz of the band. My first subsequent visit to 14.060 yielded a two-way NC20 QSO with W0MS and a nice chat with guru Rick Campbell, KK7B. Since then I've installed Dave's AGC mod and while I'm not sure it's working the way it should, for now it's more fun to operate than to troubleshoot. I'll leave that for sometime when there's a solar flare.

I'm in awe of Dave, AD6A, for his design skills — not just for the circuit, but for executing it on a "wireless" board that an out-of-practice desk jockey like me could get to work on the first try (almost). The receiver is a joy to listen to. I'm equally in awe of Doug, KI6DS, for managing (and especially for kitting) the project. I know there are many others who have made essential contributions to the NC20 project; my hat's off to you all.

The next time someone whines at me that "hams don't build equipment any more," would you guys be kind enough to beat them up for me? 72, Dave, K1ZZ

QRP Fun At 1999 Ft. Tuthill QRP Symposium

SPONSORED BY THE ARIZONA ScQRPions QRP CLUB

The Third Annual Ft Tuthill QRP Symposium will be held at the Ft. Tuthill County Park, south of Flagstaff, Arizona, on Saturday, July 24, 1999. This Symposium will feature speakers noted in the QRP community, and will offer the opportunity to meet and mingle with some of the notables in the QRP world.

Co-located with the largest Ham-Fest in the Southwest, in it's 47th year, QRP-ers will have a chance to hear talks on topics of interest to all in the hobby, meet with some of the rig designers, see QRP equipment from various vendors and generally have a great time in the cool pines of Northern Arizona.

There is a group campground available, reserved for QRP-ers, for those wishing to stay on-site. There are numerous motels and hotels in Flagstaff for those not wishing to 'rough' it. See **http://www.extremezone.com/~ki7mn/tut99.htm** for more information.

This is one of the premier QRP Forums on the QRP circuit, and is a very pleasant place to spend a weekend in the dog days of summer. Bob Hightower, Brian Kassel, Roger Hightower, and the rest of the Arizona QRPers do an outstaning job of hosting this event that draws some of the biggest names in QRP. One of the special guests this year will be Dave Benson, NN1G from Newington, CT, designer of the NN1G Transceiver, NE40-40, NE40-30, Green Mountain series of CW Transceivers, White Mountain series of SSB Transceivers, the Frequency Mite, the SWL 40, 30, 20, & 80 series that was the basis of the popular Elmer 101 series in QRPp and on QRP-L, and his latest design, the DSW with built in Keyer, AFA and Digital VFO. Dave was inducted into the QRP Hall of Fame this year and is a popular speaker and designer well known in QRP Circles.

One of the nice features of Ft. Tuthill is that there is no charge for the QRP Forums and activities. Come and join us for all the fun in Flagstaff in July.

The NorCal 20 Design

by Dave Fifield, AD6A

****

Doug said "Design us a proper rig,
That's robust, like a Soviet MIG,
With a receiver that doesn't fold,
And a transmitter that does what it's told,
And make it, oh, about yay big"....

****

Preamble

Wow! We did it! The NorCal 20 kit completed and shipped. It was a marathon task but, with the help of the whole NorCal 20 team who did a marvelous job all round, all the little last minute tasks got done. Everything seemed to just come together right, in the end. Please excuse the long thanks list below, but it's the least I can do to bring all these wonderful people a little fame and attention for all the unstinting hard work they put into (and will continue to put into...) this huge project. Please join me in thanking them all.

Thanks to Doug, KI6DS, who procured all the parts for the kits and, with several NorCal members, spent hours and hours putting the kits together. Thanks to Jim, WA6GER, who did the manual photocopying, the final bundling of the kits and the shipping (everyone got theirs, right?). Thanks to Mike, K1MG, who conceived, designed and coded the AFA chip that is in every NorCal 20. Thanks to Doug, KE6RIE (got it right this time Doug, okay?!), for providing the superb cases for the kits. Thanks to Dave, W6EMD, and Gary, AB7MY, who spent many hours testing and fine tuning the prototypes as beta builders. Thanks to Gary, N2JGU, and Brad, WB8YGG, for re-working their TiCK design to suit my demanding design criteria. Thanks to Paul, NA5N, for his power-amp design experience, advice and RF measuring. Thanks to George, G3RJV, and his helpers in the G-QRP club for agreeing to provide the third-world distribution for the giveaway kits. Thanks to Jerry, WA6OWR, for providing WWW design and publicity. Thanks to Rich, KI6SN, for editing the manual (and for the great write-up in Worldradio! – Guys, if you don't already get Worldradio, you should – it's a great read with up-to-the-minute ham radio news/articles/commentary). Thanks to all our suppliers who gave us the breaks in the prices that we needed to make this project a success. Finally, thanks to my wife, Caroline, KF6MOV, who put up with so much during the development of the rig.

Phew, hope I didn't forget anyone! If I did, please forgive me, and accept my praise and thanks for a job well done. Now, on to the technical stuff that y'all are really reading this for!

Many of you will have seen my presentation of the design of the NorCal 20 at last year's Pacificon (or QRPacificon as we affectionately nickname it now!). Since then, the design of the rig changed a bit and the layout of the board quite a bit more! We held back until we had just about every little bug worked out of the design before we committed to shipping kits. Well, *nearly* every little bug – we had to ship the rig with non-optimal AGC, as many of your ears can attest! More on that later – if you didn't know, there is a nice easy-to-do modification that makes the AGC real smooth and much better all round.

The 5-page schematic (as the kit was shipped) is in the center foldout section of this edition of QRPp. I will refer to this in my missive as we go through the design description. The design philosophy was to make a single-band rig that would hold its own against the big boys in contests, DX pile-ups and in areas of the world where there is lots of short-wave broadcast QRM and crossmodulation in lesser receivers. Unlike many of my predecessors, I didn't try to minimize the quiescent current on receive, rather, I tried to maximize performance (within budget, of course!).

VFO

Right back in the very beginning of the project, Doug and I decided that the rig would have to have a VFO. We were not happy with the limited frequency coverage that you get with VXO designs. I decided the VFO would be a more-or-less standard Hartley oscillator using an FET. I have always had good luck with these oscillators stability-wise (the NorCal 20's VFO is pretty stable too, so my decision was a good one I think!). I also decided, in the interests of cost and component availability, that the VFO would be varicap diode tuned. Using a varicap diode to tune a VFO adds thermal stability, linearity and other design complications to think about. After many different versions and tweaks, the final design was deemed a) repeatable, b) stable (enough) and c) linear (enough) for use in the kit…phew!…it was a lot of hard work – the most difficult part of the whole design.

Check out the first sheet of the schematic. On this sheet you will see, from left to right, the tuning voltage generation circuit for the varicap diode, the Hartley oscillator and the buffer/amplifier. Let's take each of these in turn.

The tuning voltage needs to be such that we use the most linear region of the varicap diode's capacitance curve that we can. For the chosen varicap, the MV209, this means a tuning voltage that starts at +2V and goes up from there. Below +2V, the capacitance change per Volt is almost logarithmic – it gives a big swing in capacitance, but it is really non-linear, so I didn't want to use it. The op-amp, U1, provides an output swing that can go from approximately 2V above its negative rail voltage to approximately 2V below its positive rail. Since the negative rail (pin 4) is GND and the positive rail is about +12V, this gives us a useful swing of about 2 to 10V to play with. Isn't it convenient too that the minimum output voltage (2V) that we can use from the LF351 op-amp is also the minimum voltage that we want to use on the varicap diode? It was fate, guys, when I saw this, I knew it was right!

Ergonomics tests done with both 1 turn and 10 turn pots led me to provide a reduced range when a 1 turn pot is used. The maximum usable (easy to tune around/set the VFO) range for a 1 turn pot seems to be about 30 to 40 KHz. For a 10 turn pot, the maximum usable range seems to be about 70 to 100 KHz. Changing the feedback resistor in the op-amp circuit changes the gain of the circuit and allows us to easily set the output voltage swing range a bit lower when a 1 turn pot is to be used.

The TUNE pot's voltage range is set by resistors R1 and R100. R1 sets the 2V end of the tuning voltage to the varicap diode and R100 sets the 10V end. This doesn't seem right does it? Once you consider that the op-amp is INVERTING, then it does make sense (hopefully!). The fancy links that you see around the TUNE pot are there to allow us to turn the pot around (electrically). You see, I found that 1 turn and 10 turn pots tune the band in opposite directions! Having the links there allows the user to set the rig up so that the

20m band always tunes from low to high frequency-wise as you turn the TUNE pot clockwise (can I patent this idea?).

You'll notice that the voltage for the TUNE pot and for the mid-point reference voltage (on pin 3 of U1) are both derived from the VFO's clean +8V supply rail. The tuning voltage must be very stable and not vary when the rig is operated from any power supply from about 10V to 14V. The 8V regulator, U2, does this nicely – well, in most cases it does! – it seems there were a few "rogue" regulators that slipped out with some of the kits, meaning that some of you had to replace them in order to get a chirp-free transmit output (we're very sorry about that, but hope you all learnt something from it!).

The nice thing about the op-amp circuit I used to generate the tuning voltage is that it has what is known as a "summing node" at pin 2, the negative input terminal. This allowed me to add RIT fairly simply, by adding in another voltage that varied the VFO frequency up or down a little from the transmit frequency. The tricky part of this design was finding a way to remove the RIT voltage from the summing node during transmit. I tried all sorts of designs and experiments, none of which worked. Then, late one night as I was racking my brains for a solution, I was staring at a bunch of old British electronics magazines (called ETI for the curious) and found a section called "101 useful circuits" – in there was an analog music synthesizer sample-and-hold circuit (for the key voltage) that used a simple FET switch and op-amp. That was the answer! A few minutes later, I'd designed the circuit values and was breadboarding the circuit that you see before you. Later on, I further realized that this is also the commonly used FET switch technique that is used to MUTE receivers. I limited the range of voltage that the FET had to deal with from source to drain (it's reversed one way round, if you think about it). Some FETs couldn't handle more than a couple of volts before reaching their pinchoff voltage. Later, after we shipped the kits, we found that some of the MPF102's shipped are no use at all in this configuration (they vary wildly apparently). The belated answer is to change this device to a 2N5457 or J309 FET (pin-for-pin compatible) – only bother doing this if you are having chirp problems on transmit though. To prove that this is what's causing your chirp (whoop), temporarily lift one end of R5 – if the chirp goes away, Q1 is your culprit, if it's still there, change out the 78L08 regulator (U2).

An 8V tuning voltage swing that results in about 70KHz tuning range gives us about 1.14E-4V/Hz. To get a 20Hz shift in the TX output frequency, this means a 2.28mV change in the tuning voltage. That's not a lot is it!. Some people have speculated that this swing is coming from the 12V connection to U1 not being regulated. The math says otherwise – the LF351 chip has a 100dB power supply rejection ratio. This means that to create a 20Hz shift, the power rail would have to vary by around 228V. This, clearly, is not the source of the small shift some people are seeing.

The output of the VFO FET is fed to a standard shunt-feedback buffer amplifier that buffers and amplifies the VFO signal (shock!). The input impedance of the buffer-amp is approximately equal to the reactance of C8 at 5MHz (3.183K) in series with R12 (12K). This comes to just a little over 15K, not too high, but high enough. The gain of the buffer-amp is roughly equal to –R14/(C8||R12) = -47K/15K = -3.13. This is just enough to get the output signal at the emitter of Q4 to be large enough to drive +7dBm of signal into the local oscillator port of the double-balanced mixer U3. The output level at this

point will vary a bit depending on the gain of the FET used for the VFO (Q2). The manual mentions this as being the prime suspect if you aren't getting enough TX output power.

The signal at Q4's emitter is distorted somewhat by the non-linear load presented to it by the local oscillator port of the RX mixer, so a clean version of the VFO signal is tapped off the collector of Q3 to feed the transmit mixer. This reduces output spurii in the transmit spectrum.

Receiver

We got a big break early on in the design cycle when Dave Gauding NF0R, Jim Smith N0OCT and Lee Johnson KE0MC of the St.Louis QRP Club found us some nice +7dBm high-level double-balanced mixers (Minicircuits TFM-2, very similar to the more usually seen TUF-1 mixers) at a vastly reduced price. This basically enabled us to add a bunch of features to the rig that made it what you see before you – a complete package with just about all the features you need to "go get 'em!". This mixer enabled me to design a pretty good receiver front-end – I hope you agree!

Turn to the second sheet of the schematic. This sheet contains the RF sections of the receiver. The signal from the antenna jack arrives at the top left of the schematic as the signal RXIN from sheet 4. If you turn briefly to sheet 4, you will see that the RXIN signal comes from the transmitter harmonic filter input. On receive, the harmonic filter is used in reverse (the filter characteristic is the same either way round), so it pre-filters a lot of garbage at frequencies higher than 14MHz and stops them from becoming a problem in the receiver front-end.

Back on sheet 2, TC2 and L2 form a series tuned resonant circuit on 14MHz (the series tuned circuit is a very low impedance at resonance, as you will recall) allowing receive signals to pass through to T1 without much attenuation. On transmit, the diodes at the junction of TC2/L2 (a high impedance point) conduct to limit the RF voltage going into the receiver so no damage is done. This circuit is commonly called a T-R switch. I claim no originality for its design.

Receive signals are then passed through a fairly narrow (my calculations showed about a 150KHz bandwidth here) double-tuned bandpass filter. This filter rejects out-of-band signals that may cause imaging or crossmodulation problems in the receiver. The filter is a fairly standard design. It has about 4dB of loss. A novel feature is the RF attenuator arrangement that I came up with. Instead of using a mismatched 500Ohm pot on the input side of the filter like most of my predecessors, I came up with a new approach that proved to be both matched (better matched anyway!) and cheaper. I noticed that the impedance in the center of the filter was about 10 to 12K and thought "why don't I just used a standard 10K pot at this point in the circuit?" I couldn't think of any reason why not, so I tried it – it turned out that it actually works very well indeed (another patent application here?).

To overcome the 4dB loss of the front-end filter and the –6dB loss of the double balanced mixer, I used a fairly standard FET front-end pre-amplifier (Q5). This pre-amp has about 8dB of gain and provides the receiver with a fairly low overall noise figure (about 8dB, but this has not been measured yet). Dave Meacham (elsewhere in this issue I think) suggests that the noise figure/match into the pre-amp can be improved by reducing the number of turns on T2's secondary to 3 turns (instead of 4). I haven't tried this, but it is worth considering this mod.

Without some form of VHF/UHF

damping, the pre-amp would simply become a VHF oscillator. The normal method of controlling this is to use a small ferrite bead on the drain lead of the FET. I found this method to be too expensive and somewhat microphonic as well. A simpler, cheaper solution to this problem is to add a small series resistance in the drain lead. This kills the VHF/UHF gain of the stage totally (thanks to Mr. Miller and his effect) and makes the pre-amp unconditionally stable. It does knock a tiny bit off the HF gain, but we have enough that we don't need to worry about it here.

The drain circuit of the pre-amp is broadly tuned to 14MHz and impedance matched to the RF port of the double balanced mixer using a capacitive tap. Again, I believe Dave Meacham has a useful mod that improves the match and Q of the tuned circuit here.

The double balanced mixer (U3) mixes the VFO signal with the band-limited receive signals to produce a whole spectrum of first, second, third (ad infinitum) order mixer products at its IF port. We are only interested in the first order product of the input frequency (20m band) minus the VFO frequency, that is, the IF frequency of 9MHz.

However, we have to do something with all those other mixer products to stop them from upsetting our receive mixer. We need to terminate them all in 50Ohms. So where's the 50Ohm termination resistor you ask? Well, the post-mixer amplifier takes care of terminating both the wanted signals at 9MHz and all the unwanted stuff up and down the spectrum. Q6 provides an approximate 50Ohm termination for all the frequencies that matter to us here. Since there can be quite a lot of energy at the unwanted mixer product frequencies, we have to be able to handle the total power of all these signals in the post-mixer amplifier without the amplifier itself producing its own intermodulation products from all the stuff we don't really want. This means that the post-mixer amp has to be a fairly beefy amplifier and use quite a bit of current. I used a 2N4427 device for this, rather than the more usually seen 2N5109 because it was a) cheaper and b) cheaper. The 2N4427 has very similar specs to the 2N5109 at the frequencies of interest in this design. The post-mixer amplifier has a gain of about 20dB and, with a quiescent current of about 35mA, provides an output third order intercept point (IP3) of about +25dBm. This is more than adequate to ensure good receiver performance (you can reduce the current consumption here, at the cost of receiver performance, if you like). It does mean, however, that the 2N4427 device needs a small heatsink to dissipate the power.

The output of the post-mixer amp (Q6) needs to see a fairly constant 50Ohms termination across the spectrum, since this type of post-mixer amplifier reflects its output termination impedance to its input. Therefore, we cannot simply feed the amplifier's output straight into a crystal filter. At resonance (9MHz) a crystal filter's impedance characteristic is all over the place. A simple 6dB attenuator (R30, R31, R32) provides 12dB of return loss for the signals from the post-mixer amplifier output to the crystal filter and back again. This provides the best compromise balance between signal loss and post-mixer amp termination impedance.

The 4 pole 9MHz crystal filter provides about a 300Hz CW filter bandwidth with a nice flat top response, sharp skirts (stopband attenuation is in the order of 70dB) and about 9dB of loss. "More loss?" I hear you ask, "When are we going to see some gain for a change?"

Right here – next comes the IF amplifier. Notice that this is the same type of shunt-feedback buffer-amp that was used

for the VFO. The input impedance is about 50Ohms, it has about 27dB of gain and an output impedance of about 50Ohms too. Additionally, it has fairly low noise, so all in all, it's a nice clean IF amp design.

If you're still following me at this point, you may have noticed that I haven't said anything about the AGC PIN diode gain controls along the way. I was saving that for the section on AGC later, but I guess we have to mention D11 right here, since the amplified IF signals have to pass though it at this point. D11's circuit can be considered a variable RF resistor in series with the IF signals – more about the AGC later.

The IF amplifier, because of it's fairly high gain, adds some noise to all frequencies passing through it. This includes both our wanted sideband (the CW signal you are trying to listen to) AND the unwanted sideband. There is little or no signal at the unwanted sideband, but the product detector (next thing in the circuit) doesn't care. It simply mixes (demodulates) them both down to audio frequencies. If there is a lot of noise in the unwanted sideband, this will be mixed down to audio as unwanted noise along with the wanted signals from the wanted sideband (still with me?). Since the IF amp does add noise to the unwanted sideband, this is bad. Significant improvement in the noise performance of the product detector can be had by placing another simple crystal filter just ahead of it. In my design, the product detector (U4) has some internal gain that also adds noise, but we can't do anything about that without a major re-design using more amplifiers and a passive product detector. The unwanted sideband noise filter (X5) is matched so its frequency aligns with the main filter and is designed so that it doesn't upset the nice flat top of the main filter too much.

The output of the unwanted sideband noise filter is impedance matched to the input of the NE602 product detector with a broadband RF transformer. This steps the impedance up from around 50Ohms to the 1.5K of the NE602. The NE602 contains a Gilbert cell mixer and an oscillator circuit – for your reference, the conversion gain of the NE602 is about 17dB. I use the internal oscillator as the BFO – it is running at 9MHz, with a small offset (set by TC6) that allows you to hear signals as audio tones after they are demodulated.

The differential audio output from the product detector is fed to schematic sheet 3. Capacitor C43 removes much of the unwanted high frequency noise from the audio. On sheet 3, U5a provides some useful audio gain, about 11dB, and a low pass filter characteristic that rolls off at 1298Hz. Filter-amp U5a is configured as a simple differential amplifier with gain roll-off frequency set by 1/(2*pi*RC). R49 and R50 provide the mid-rail voltage for all the audio filtering sections. C48 and C49 provide AC noise decoupling to GND from this mid-rail point.

The single-ended output of U5a passes through the FET MUTE switch Q9. Again, there have been several constructors who have had problems with bad MPF102's here. If you are experiencing clicking/thumping on key down or key up, consider changing this FET to a 2N5457 or J309A part. The FET MUTE switch is switched by the MUTE signal from the transmit control section on sheet 5. The switch output is fed directly into a bandpass filter built around U5b. Since all the inputs and outputs of the audio circuits around and about the MUTE switch are all at the same basic mid-rail DC potential, there are no thumps or clicks introduced into the audio path. I have seen several other designs, in the past, where this detail was not considered, resulting in a design that has significant RX/TX changeover transition problems (audio

coupling capacitors charging/discharging).

The bandpass filter has a center frequency of 700Hz, a mid-band gain of about 30dB and a Q of about 5. The center frequency can be altered to suit other frequencies if desired, but it was found to be adequate for most operators who like CW notes from about 600Hz to 800Hz. The bandpass filter op-amp is also pushed into service as a straight inverting op-amp to amplify the sidetones from sheet 5. The SIDETONE signal is fed straight into the inverting input of the op-amp where it bypasses the filtering effect of the bandpass filter arrangement.

The audio output from the bandpass filter is fed directly to the AGC circuits. A small attenuator formed by R56/VR4 cuts the audio signal down to a level where the main audio amplifier can handle it without distorting. The LM380N audio amplifier was chosen because it can easily drive 1W of clean audio into a small loudspeaker. The more ubiquitous LM386 just doesn't have enough poke to drive most loudspeakers that I have tried, and I invariably end up being disappointed with the result. The LM380 does have quite a lot of gain though, hence the need to attenuate the audio feed to it (we need the full audio level from the output of the bandpass filter for the AGC circuits however).

Capacitor C57 decouples a lot of high frequency audio noise to GND and keeps the LM380N from sounding too "hissy". R58 and C61 form a Zobel network at the output of the audio amp – this provides very high audio frequency roll-off and keeps the audio amp happy when driving inductive loads. Audio output is by means of a stereo jack – or there is room to put a small loudspeaker right in the case of the NorCal 20. Notice the output is from a STEREO jack – you wouldn't believe it, but I had a few cases where people complained of low output that I eventually diagnosed as them using MONO jacks plugged into the stereo output jack socket! Of course, the audio was shorted out!

AGC

The AGC system was added to the requirements about halfway through the project. Several hams, who had played with early prototypes, insisted that we add AGC! Looking back, I think they were right. Without AGC, the receiver is a pain to use – you have to keep one hand ready on the RF attenuation pot all the time as you tune the band – if you want to protect your hearing that is!

Adding AGC to the receiver was not an easy task. I experimented with several different arrangements of PIN diode attenuators (before the RF pre-amp, after the RF pre-amp, after the post-mixer amp, before the IF amp etc.). Some of theses arrangements were disastrous, for example, a PIN attenuator place between the RF pre-amp and the mixer resulted in the VFO frequency being pulled by strong signals which resulted in "whoop" on receive! In the end, I settled on one PIN attenuator after the IF amp (D11) and two more PIN diode variable gain amplifiers. The first of these (D9), added to the RF pre-amp, doesn't have much affect on the RF gain at all, and the second (D10), added to the emitter circuit of the post-mixer amplifier has a fairly big effect on the post-mixer amp gain. The third (D11) is an in-line attenuator that contributes quite a large amount to the AGC attenuation range (approx. 30dB if I recall correctly). These three stages of AGC were found to be inadequate in dealing with the range of gain variation required for "good" AGC function – the AGC needed far more range.

Back at the drawing board, I scratched my head for quite a while – I didn't want to have to start using MC1350 I.F. amplifier chips (noisy and expensive), but how

else was I going to get the gain variation required? Then I recalled Wayne Burdick's SST design with the simple AGC that he'd come up with built around his product detector and AF amplifier. Wayne had discovered that, by applying a common-mode DC voltage to the input pins of the NE602 device, you could vary its conversion gain quite a bit. That was it – I was using an NE602 for my product detector, so I could do the same thing. Well, I refrained from using a low voltage red LED as per the SST (I found it very distracting) and went for a simple set of series diodes (D19-21) to get the right AGC voltage from the audio. It worked pretty well (or so I thought!). This was how the kit was shipped – with two AGC loops (independent of each other). However, as many of you will testify, the AGC action on strong signals was far from ergonomic – it absolutely clobbered the signals down to nothing, then slowly released a little audio – someone aptly coined the phrase that it "sounds like someone hitting it with a baseball bat".

Well after all the kits were shipped, Dave Meacham revisited the AGC design and came up with some mods that would ease the baseball bat action a bit, but still wasn't really what you'd expect from a nice smooth AGC response. I dug into the design a bit more and decided that part of the problem was that the two loops weren't progressive and were unconnected. The rig needed just one AGC loop or something far more complex in the way of controlling the two loops together. It wasn't long before I realized that I could very easily feed the NE602 with an attenuated version of AGC2 and things should work quite well. A quick bit of math found the attenuator resistor values 2.2K and 680Ohms would do the trick nicely. I tried it. WOW! What a difference! The AGC was now really smooth acting and had waaaaay more range than it ever did before. I was impressed. I found that by removing the first AGC PIN diode stage it made next to no difference in the AGC range and action, BUT it did make a big difference to the intermodulation performance of the RX front-end – I decided to take it out. The modification details are elsewhere in this magazine.

Guys, this modification is a "must do". The improvement is huge – my NorCal 20 prototype has over 110dB of AGC range now – signals up to +10dBm at the input do not bother it! You will find that you rarely need to use the RF attenuator control on the rear of the rig after you do this mod.

Transmitter

I spent a lot of time on the transmitter design. Many circuit ideas and canned designs were tried – all but the final design had flaws. I wanted a simple, cheap transmitter design that would be variable from 0 to over 5W output, very stable, very clean and easy to tune up. The first prototypes used and IRF510 MOSFET for the final. Driving that thing was a nightmare! In the end, I gave up on it because of its terrible efficiency at anything other than full power output.

After a bit of a search, I found a nice high gain CB type bipolar transistor designed specifically for this type of application, the 2SC1969 made by Mitsubishi. This was reasonably priced and was available – a rare thing these days!

The transmitter was sort of designed in reverse – the PA transistor's gain/input power requirements set the driver stage's design requirements. The design of the output side of the PA was trivial. The work had already been done for me and published in QEX sometime last year. A simple 4:1 impedance step-up transformer (T8) brings the transmit VSWR match somewhere close to 1.5:1. The harmonic filter

from QEX was simply scaled to 14MHz. This type of elliptical filter adds notches in the transfer function at the second and third harmonics. It works very well indeed. A tiny amount of transmit RF is detected by D23 for use when setting up the VFO and transmitter.

Since the 2SC1969 has about 13dB of power gain, it really didn't need to have a hefty driver (and hence, expensive). A paralleled pair of PN2222A transistors were all that was required to do the job – guess where I got that idea from? The NorCal 2N2222 design contest of course! The two transistors share the collector current. Resistors R77 and R78 ensure even load distribution between the two transistors and also set the gain for the stage. I designed the output of the driver stage to be broadly tuned to 14MHz. This is achieved with the inductance of the primary of T7 with capacitor C76. I have not seen this technique used anywhere before, so unless I hear otherwise, I claim the bragging rights as its inventor. "So what?" you ask, "big deal!" – well, it is a big deal – making the intercoupling between the driver and the PA tuned like this VASTLY improves the output spectrum and tames the whole transmitter from taking off at frequencies other than the required 14MHz (another patent maybe?). This filtering effect plus the elliptical harmonic filter on the PA output add together to produce the cleanest output spectrum I have ever seen from a QRP kit. The harmonics are at least 70dB below the main carrier – better than most commercial rigs! The mixer generated spurious outputs aren't too bad either, being at least 54dB below the main carrier – these could be improved using a more sophisticated design (a more balanced mixer or maybe a DDS?).

The driver stage designed, I needed about 0 to 4V peak to peak to drive the driver. Our old friend the shunt feedback amplifier handles this nicely. Q14 and Q15 form the amplifier that has a gain of about 22dB at 14MHz. C105 was added to ensure stability at frequencies much higher than 14MHz (it kills the VHF/UHF gain of the circuit totally). The output of this amplifier takes the form of an emitter follower – simply tapping the emitter resistor provides drive from 0 to 4V p to p (VR6) which sets the output power anywhere from 0 to about 7W.

Prior to the shunt feedback amplifier is the transmit mixer and double tuned filter. U7, an NE602 provides the 9MHz needed to mix with the 5MHz VFO frequency. Transmit offset is handled in the same way as receive offset – TC7 adjusts the offset to match the receiver, so when you transmit you are on exactly the same frequency as the fellow you are calling. The VFO input level to the transmit mixer needs to be carefully controlled. Dave Meacham suggested using a capacitive divider to do this accurately and in a way that will allow the probing of this point with test equipment (e.g. an oscilloscope) without it having much effect on the signal level itself. A resistive divider with the same signal levels would be grossly affected by the adding of an oscilloscope probe on pin 1 of U7.

The differential output of U7 is tuned to 14MHz by the primary of T5 and C70/TC8. T5 is loop coupled to T6 – this method does two things for you, a) it converts the balanced signal to unbalanced in T6 and b) it reduces the level of unwanted lower frequency spurious signals that are generated in the mixer section of U7. T6's secondary is resonated with TC9/C71 to 14MHz.

The net result is a transmitter that meets all the design goals that I set out to achieve. Please feel free to plagiarize any or all of the transmitter design for your next project.

TiCK Keyer & TX/RX Timing Control

The TiCK keyer chip from Embedded Research was chosen because it has a nice set of features and Brad/Gary were willing to do a bit of alteration to the device to suit my design requirements for the NorCal 20. I wanted them to do some special things with the audio output drive so I could have a simple, thump-free sidetone in the rig. Sidetone from pin 3 is first filtered by R82/C89, then level adjusted by VR7 and then fed via a very small capacitor, C96, to the audio amplifier stages of the rig.

The TiCK keyer chip has all sorts of essential keyer features such as paddle swap, speed adjust, weighting adjust, iambic mode A or B, straight-key mode etc. An added bonus is that the TiCK III (sometimes called Super TiCK) chip, that contains even more features like memory and beacon mode, is a drop-in replacement for the TiCK I in the NorCal 20. This allows users to upgrade real easily. The TiCK's features are programmable using a front panel mounted push-button switch. All TiCK setup data is lost when the rigs power is removed.

The digital output of the TiCK keyer drives the base of Q19. Q19 is a simple NPN switch. When a paddle is pressed, TiCK pin 5 goes to logic 1, which turns transistor Q19 ON. This pulls the base voltage of transistor Q20 towards GND, which turns transistor Q20 ON. Q20 is normally held in the OFF state by R85. The voltage at the collector of Q20 does not immediately go straight up to 12V though, instead, because of C94 charging, the collector voltage ramps linearly up to 12V in about 1.5mS. This controlled edge turn-on causes the transmitter output envelope to also have a nicely controlled rise time, hence occupying the minimum necessary bandwith. At the end of transmission of a code element, the TiCK output (pin 5) returns to 0V switching transistor Q19 OFF again. This turns Q20 OFF again, but this time, because of the charge already held in C94, the collector voltage cannot immediately go to 0V – it ramps down linearly in about 2mS, controlling the falling edge of the transmitted RF envelope in a similar manner as the leading edge.

The receiver MUTE and RIT circuits need to be switched for the RX to TX and TX to RX transitions. Switching transistor Q21 turns ON pulling the MUTE line to 0V during transmission. This transistor ensures that the receiver is muted and the RIT is OFF before the +12VTX line is up and the transmitter active and, through R98/D26, that the receiver remains muted until the transmitter has stopped transmitting. There is another modification that can be made to the circuit here – to extend the time that the receiver is muted after transmission. This modification is also provided elsewhere in this edition of QRPp.

AFA

The Audible Frequency Annunciator (AFA) measures the VFO's frequency, does some clever math on it and converts the result to an audible Morse code annunciation of the last two KHz digits of the actual frequency the rig is tuned to on 14MHz. Thus, for 14.060MHz, the AFA will announce "60" in Morse code. The AFA has two modes of operation, Auto and Manual modes. Auto mode is where the AFA sends a very short "pip" every time you tune through a 1KHz point on the dial, and then, when you stop tuning, announces the frequency you stopped on after a few seconds. Manual mode is where you press a front panel mounted push-button switch every time you want to hear the AFA announce the current frequency. Mode selection is by board mounted links. A small slide switch can be mounted in the mode link holes and a corresponding hole cut in

the bottom of the case to allow access to it – if you'd like to be able to change modes on the fly.

The audio output on pin 7 of the AFA is treated in the same way as the audio from the TiCK keyer – VR8 sets the audio level. The AFA needs a reference frequency to compare to, so requires a 100KHz crystal. It contains the circuitry needed to turn pins 2 and 3 into an oscillator. The output level of the VFO is too small to drive the digital input of the AFA directly, so our old friend the shunt feedback amplifier comes to the rescue once again! Q22 and Q23 form the amplifier that provides about 4V peak to peak signal for the AFA. D27 and R96 stop the VFO signal from being amplified during transmit. This was found to help reduce the incidence of spurious announcements by the AFA during transmissions, when the AFA was in Auto mode.

Conclusion

The astute will notice that the basic design of the NorCal 20 is fairly easily adaptable to other bands. Although the NorCal QRP Club won't be offering this design for other bands, the new "High Performance Ham Radio Kits" company called "Red Hot Radio" that I have formed to ensure a supply of these neat radios, will. You can check out the Red Hot Radio website at http://www.redhotradio.com for more information. The instructions for converting the NorCal 20 into a Red Hot 40 are on the web, as are all the modification details mentioned throughout this article. If you missed out on the original club kits, you can order a Red Hot kit from here too.

That's enough advertising. Folks, I must say it was a real pleasure and immense fun to do the design work on this radio. Please write to me if you have any questions on the design or troubleshooting it – my email address is below.

It sure was a lot of work, but when I read emails from people whose rigs work nicely (first time!) and hear people on the air actually using them, then all memory of those late nights fade away to nothing and I'm left feeling proud and very, very satisfied with a job well done. See you on 20m!

72, Dave Fifield, AD6A
support@redhotradio.com

NC20 Transmit Timing Mod to Cure "Real" Sidetone THUMP

by Dave Fifield, AD6A

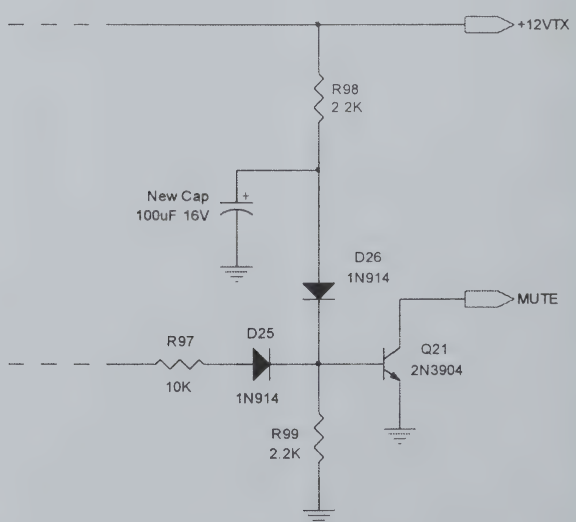
If you have tried to use the "real" sidetone from the NorCal 20's receiver, you will no doubt have been put off by the loud clicking (a.k.a. THUMP) that accompanies the end of each Morse code element. Some radios will be affected more than others depending on their exact transmit timing. If you do the AGC mod that I suggest then you won't be able to use "real" sidetone mode at all since the mod ties the product detector into the main AGC loop, which means on transmit, the product detector is completely shut down (by the MUTE line). I'm working on an alternative mod that will allow you to have both nice clean modified AGC and be still be able to use "real" sidetone mode, but I'm not there yet, so you'll have to wait a while longer. For now, whether you are doing the AGC mod or not, this timing mod is worth doing. In fact, on some rigs, after the AGC modification has been performed, there will be a slight amount of clicking even using TiCK sidetone until you do this mod.

The reason for the slight thump/click is that the MUTE switch, transistor Q21, is turning off too fast at the end of each transmit element (Morse code element). This is due to the current available from the falling

+12VTX line not being sufficient to keep Q21 turned on for very long, allowing a small amount of the tail end of each transmit element to get into the now unmuted receiver, leading to a rather nasty pulse throughout the whole receiver chain. A simple cure is effected by changing the value of R98 from 10K to 2.2K and adding a 100µF 16V "hold-up" capacitor to the junction of D26 and R98 as shown in the diagram below:

At the start of each transmission, the 100µF capacitor charges up fairly rapidly through R98. At the end of each transmit element, as +12VTX falls, the charge in the capacitor continues to supply current to the base of Q21, keeping it turned on for a few more milliseconds. This keeps the MUTE signal low long enough for the transmission to completely cease, allowing the receiver to completely recover without any THUMP. The upper limit of the rig's QSK speed is affected by this modification, but normal operation at up to 40+ wpm seems to still be fine. You may like to play with the values of R98 and the new capacitor to fine tune the mod for your rig – there will be some differences between rigs.

With this modification in place (though not the AGC mod) and with R52 = 5.6K, the "real" sidetone is a pleasure to use. Of course, this means you have to manually turn off the TiCK's default sidetone each time you turn on the rig, but you may consider this a small price to pay for being able to hear exactly what the transmit offset is. 72 es GL, Dave Fifield, AD6A



TWEAKING THE NORCAL 20

by Dave Meacham, W6EMD
206 Frances Lane
Redwood City, CA 94062
Internet: ddm@datatamers.com

Here are seven mods that I developed on my prototype rig after the NC20 design was firmed up and the manual printed:

1) Revised crystal filter:

This mod gives a narrower bandpass, much better match, and 2dB lower insertion loss. The only penalty is a rounded top on the response curve...you hardly hear it. Change the capacitor values to the sequence 1200pF, 680pF, 1200pF, 680pF, 1200pF (C30 through C34).
Return loss = 23dB
Insertion loss = 7dB
Bandwidth = 480Hz @ -6dB points

2) Revised roofing-filter:

This mod centers the response curve better on that of the main filter. Change C38 and C39 to 820pF. On the underside of the board cut the trace between C36 and the emitter of Q8. Scrape off the solder mask on each side of the cut, and solder a 120-Ohm resistor across the cut.

To avoid cutting any trace, Gary Surrency suggests lifting one end of C36 and soldering the 120-Ohm resistor in series with it (above the board). To save some money, Dave Fifield suggests using the two 680pF caps removed from the roofing filter for the revised main filter, and the two 820pF caps from the main filter for the new roofing filter. He also suggests simply adding three 390pF caps underneath the PCB in parallel with the remaining three 820pF caps of the main filter to bring them up to 1210pF, instead of having to replace the 820s with 1200s.

3) Hiss fix:

This mod kills the hiss from U6, but is useful only for headphones. Cut the trace (on the underside of the board) from C62 to J1 (close to C62). Jumper the cut (as above) with a 39-Ohm resistor. Add a 22uF tantalum capacitor from the hot terminal of J1 to ground (negative to ground). Change R56 to 10k Ohms. (This is a refinement of the mod mentioned in the manual.)

4) Preamp fix:

This simple mod improves the MDS (receiver sensitivity) by more than 1dB. Just add a 220pF capacitor (under the board) across C22. I used a C0G mono cap. Retune TC5 for maximum signal. If you run out of tuning range, spread the turns on L3, or, in an extreme case, remove one turn. This mod increases the load impedance seen by Q5 from 365 Ohms to 1200 Ohms, and increases the loaded Q of the tuned circuit from 2.3 to 8.8. You will notice the sharper tuning of TC5.

5) BPF match:

Remove one turn from the secondary of T2 so that it becomes 3 turns to give a better match. Change C17 to 3.9pF or 4pF, NP0 or C0G type.

6) Output low-pass filter:

Change L6 to 8 turns, and L7 to 7 turns. Change C80 to 300pF (two 150pF caps in parallel). Be sure and use 100V NP0 or C0G caps. Remove C82. These changes improve the harmonic attenuation and the matching.

7) Reactive T4 fix:

The stock T4 suffers from a low inductive reactance of about 2.9k Ohms re-

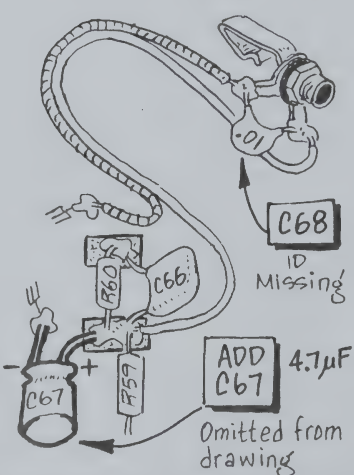
ferred to the secondary. The load is 3k Ohms resistive in the NE602. Increasing the inductive reactance gives a more resistive termination for the roofing filter, resulting in better performance. Just change T4 to 4:22 turns of number 28 wire, or (better yet) to 6:33 turns of number 30 wire (harder to wind). I think you will like the improved performance. 72, Dave, W6FMD

The 2N2/40 ADDENDUM

The errors and omissions discovered in the 2N2/40 construction article (WINTER 1998 QRPp) by various builders and the designer, Jim Kortge K8IQY, are detailed and illustrated below. In most cases, schematics are correct - with a few parts omitted from the drawings.

1 T-R SWITCH

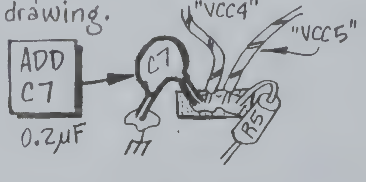
CHANGES TO PAGE 17



2 The VFO

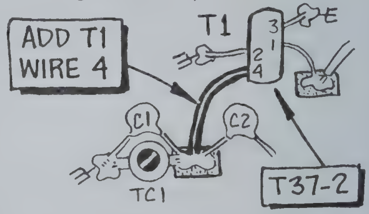
CHANGES TO PAGE 19

Capacitor C7 omitted from drawing.



3 The FRONT-END

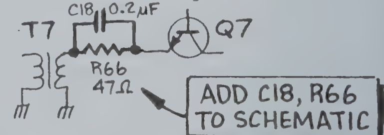
CHANGES TO 23



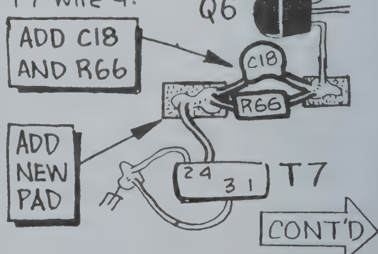
4 The I.F. AMPLIFIER

CHANGES TO PAGE 25

DESIGN CHANGE for better IF Amplifier stability.



ADD C18 and R66 between Q6 emitter and T7 wire 4.

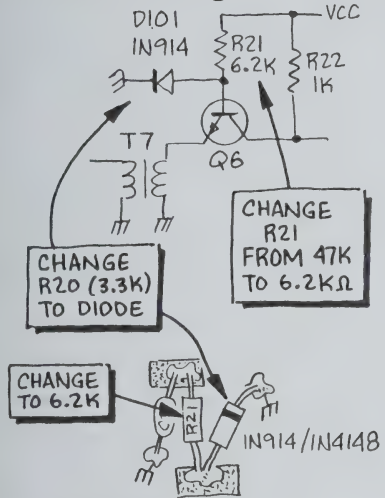


CONT'D

④ The I.F. (Cont'd)

CHANGES TO PAGE 25

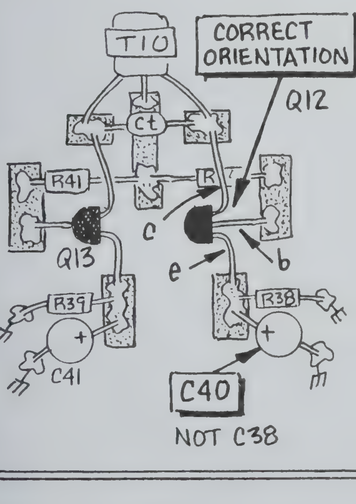
An alternative to adding R66 is to use a diode in place of R20 for proper biasing.



⑥ AUDIO AMPLIFIER

CHANGES TO PAGE 31

The orientation of Q12 is incorrectly drawn – proper placement shown here.



⑦ TX AMPLIFIER

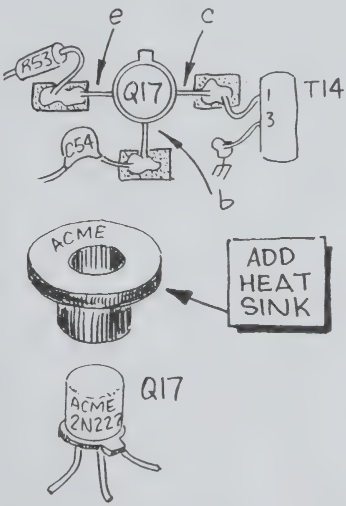
CHANGES TO PAGE 35

Toroidal transformers T12 and T13 are wound on T37-2 cores, not FT37-2

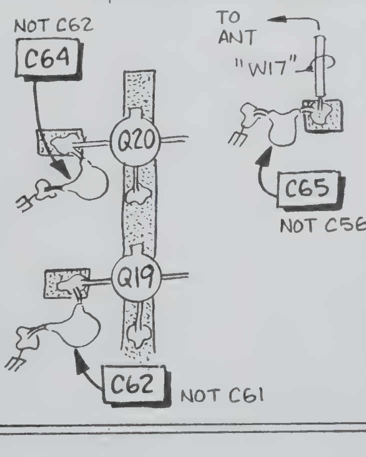
⑧ The PA Stage

CHANGES TO PAGE 37

TX Driver transistor should be a TO-18 (metal can) 2N2222A with a heat sink.



Three capacitors are mislabled:



SOME 2N2/40 GOODIES...

The ScQRPion Screened Board.

The AZ ScQRPions have made a copper clad board for the 2N2/40 with the location of all the pads & major components screened into place. This uses the illustration on page 13 of the Winter 1998 QRPp. The 2N2/40 winner at the Ft. Tuthill hamfest used this board for a neat, clean build. Extra copper clad provided for making the pads. Available for $5.00 from:

BOB HIGHTOWER, KI7MN
1905 N. Pennington Dr.
Chandler, AZ 85224

2N2/40 UPDATE INFO

Jim Kortge, K8IQY, maintains a website for the 2N2/40 listing noted errors, mods, etc. For latest info, see:

www.qsl.net/k8iqy

2N2/40 AM QRM?

From Elliott Lawrence, WA6TLA

Elliot lives very close to a 50KW AM station that was ever-present in the audio stage. He cured it by adding a 1000pF (.001µF) cap on the Q11 audio preamp, from Q11-base to ground. A 4700pF cap eliminated the QRM completely – experiment for good value without shunting audio gain.

2N2/40 CERTIFICATES

Have you built the 2N2/40? Preston Douglas, WJ2V, himself a 2N2/40 builder, has made a handsome certificate to award those who build the rig. They are also serialized. To get yours, send the following to Preston:

1. 9x12 envelope, addressed to you with two stamps.
2. Photo of your completed 2N2/40. Photo will be returned. Photo can also be sent electronically.
3. Name, call, date & time of your first 2N2/40 QSO.

Send to:

PRESTON DOUGLAS, WJ2V
216 Harborview North
Lawrence, NY 11559

2N2/40 OUTPUT FILTER

A couple of builders have reported a little difficulty attaining a low SWR with a tuned antenna which was corrected by adding 2 turns to L6 and L7 in the output filter (for 19 turns). This is likely due to small variations in the "mu"-factor between toroids, even though all T37-2's, affecting the impedance transformation slightly of the filter.

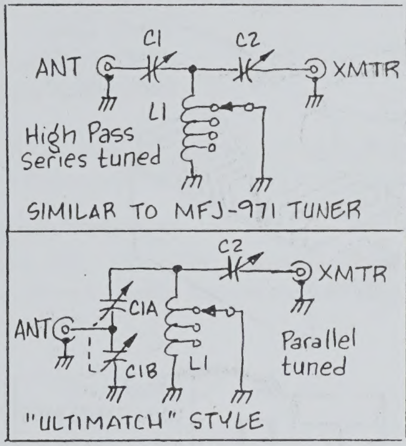
THE TRANSMATCH RECEIVER

SUBMITTED BY — WALTER DUFRAIN, AG5P
St. Louis QRP Society (SLQS)

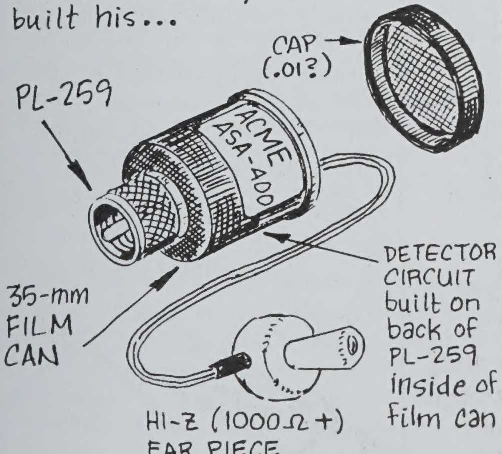
THIS PROJECT IS QRPp Y2K COMPLIANT

If you have an antenna tuner (and most QRP'ers should), you can make a nifty WWV receiver or station monitor. Antenna tuners are some form of tuned circuit and/or high pass filter. It will resonate at some HF frequency due to the L and C values selected on the tuner controls. By adding a simple diode detector, you have a crystal radio for receiving strong shortwave stations, WWV, or your own signal.

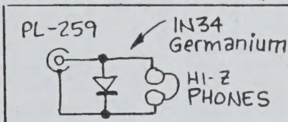
TYPICAL ANTENNA TUNERS



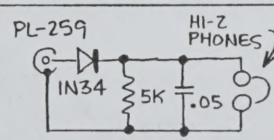
Here's how Walter, AG5P built his...



DETECTOR CIRCUITS



The simplest AM detector using Hi-Z of phones to form the audio

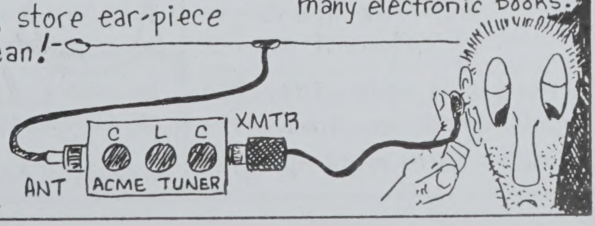


Standard half-wave AM detector

Additional AM detector circuits can be found in many electronic books.

When not in use, store ear-piece inside of film can!

Plug-in detector unit and tune in station. Record settings.



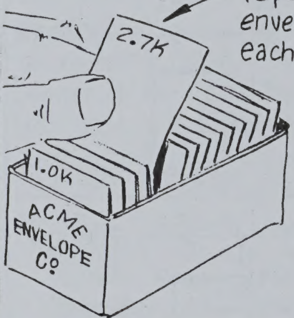
ORGANIZING THOSE PARTS...

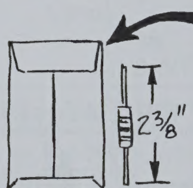
LIKE THE NORCAL RESISTOR/CAPACITOR KITS ®

USING COIN ENVELOPES

From Jim Osburn, WD9EYB

Paper Coin envelope for each value





Long Lead Resistor

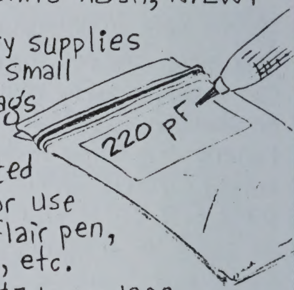
STANDARD COIN ENVELOPES	
No	SIZE
A-1	2 1/4 × 3 1/2
B-3	2 1/2 × 4 1/4
C-4	3 × 4 1/2

A box of 500 is about $10

USING POLY ENVELOPES

From Chris Trask, N7ZWY

Jewelry supplies carry small poly bags with a frosted box for use with flair pen, pencil, etc.



About $7-10 per 1000

Size: 1 1/2 ×2 and larger.

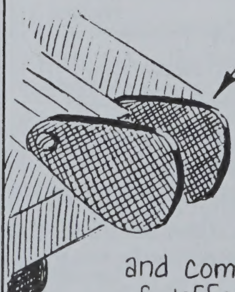
One Source is

RIO GRANDE JEWELRY
Albuquerque, NM
1-800-545-6566

Chris also reports Jewelry Supply business are also a good source for cheap small tools, pliers, boxes, etc

REPLACEMENT FINGER PIECES FOR PADDLES

From Bob Tellefson, N6WG



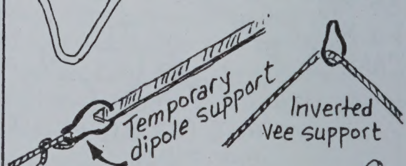
BASS GUITAR PICKS make great replacements for most paddles and come in a range of different colors.

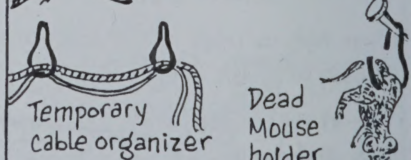
Strong and thin – they also work great on the K8FF paddles with wide spacing.

QRP TO THE FIELD GADGET

From Jan Medley, NØQT

Shower curtain holder-upper metal clip thingie





All sorts of temporary uses.

NorCal's T-Shirts

NorCal offers two shirts:The NorCal T-Shirt and The NorCal Zombie T-Shirt (Limited Edition) The price is $15 each plus $3 shipping and handling in the US, $5 shipping for DX. The shirts are the recognizable NorCal "GOLD" and high quality and heavy duty. The NorCal shirt is imprinted with the NorCal logo and the NorCal Zombie shirt is imprinted with the NorCal Zombie Cartoon. The shirts are gold with the NorCal Logos in black and the Zombie Cartoon is multicolor. To order Send $15 + $3 postage ($5 DX) to:

Jerry Parker,
426 Tanglewood Ct.
Paso Robles, CA 93446

Don't forget to specify your size: M, L, XL, XXL (Note XXL shirts are $3 additional) Please make check or money order out to Jerry Parker, NOT NORCAL, US Funds Only.

QRPp Back Issues Pricing:

1993 - $10, 1994 - $15, 1995 - $15, 1996 - $15, 1997 - $15, 1998 - $20 (Avail. Mar. 1, 1999) Full year sets available. NO individual issues available, sets will not be broken.

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$4 for 1 - 3 issues, $5 for 4 - 6 issues.

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$4 for 1 issue, $5 for 2 - 3 issues, $7 for 4 -6 issues.

Shipping: DX Europe & South America

$5 for 1 issue, $7 for 2 - 3 issues, $10 for 4 - 6 issues

Shipping: DX Pacific Rim, Australia & New Zealand

$5 for per issue ordered.

All funds US funds only. Make check or money order to Doug Hendricks, NOT NorCal. Please send orders to: Doug Hendricks , 862 Frank Ave. , Dos Palos, CA 93620, USA

QRP Frequency Crystals

NorCal has available the following crystals in HC49U cases for $3 each postage paid in th e following frequencies: 7.040 MHz, 7.122 MHz., 10.116 MHz. Send your order and payment in US Funds only to: Doug Hendricks , 862 Frank Ave. , Dos Palos, CA 93620, USA. Make check or money order to Doug Hendricks, NOT NorCal.

QRPp Subscriptions

QRPp is printed 4 times per year with Spring, Summer, Fall and Winter issues. The cost of subscriptions is as follows: US and Canadian addresses: $15 per year, issues sent first class mail. All DX subscriptions are $20 per year, issues sent via air mail. To subscribe send your check or money order made out to Jim Cates, NOT NorCal to: Jim Cates, 3241 Eastwood Rd., Sacramento, CA 95821. US Funds only. Subscriptions will start with the first available issue and will not be taken for more than 2 years. Membership in NorCal is free. The subscription fee is only for the journal, QRPp. Note that all articles in QRPp are copyrighted and may not be reprinted in any form without permission of the author. Permission is granted for non-profit club publications of a a non-commercial nature to reprint articles as long as the author and QRPp are given proper credit. The articles have not been tested and no guarantee of success is implied. If you build circuits from QRPp, you should use safe practices and know that you assume all risks.

QRPp, Journal of the NorCal QRP Club
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Dos Palos, CA 93620

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Issue
'Cuz it took 1000
years to finish :(
-The Print Shop

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